A narrative synthesis of the applicability of the CaR-FA-X model in child and adolescent populations: A systematic review

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Abstract

Background: The CaR-FA-X model (Williams et al., 2007) is the most prominent and comprehensive model of overgeneral autobiographical memory (OGM) and provides a framework for OGM. The model comprises of three mechanisms, capture and rumination, functional avoidance, and impaired executive control. These can independently, or in interaction, account for OGM. This systematic review aims to evaluate the existing research on the CaR-FA-X model, and trauma exposure studies specific to child and adolescent populations. **Methods**: The following databases were searched: 'PsychInfo', 'PsychArticles', 'PubMed', 'Web of Science', 'Medline', 'SCOPUS' and 'Embase' for English-language, peer-reviewed papers with samples < M = 18 years, published since 1986. **Results**: Support was reported for a relationship between trauma exposure and OGM as well as for capture errors and OGM. Limited support was found for rumination, avoidance and impaired executive control in isolation. No support was found for interacting mechanisms and OGM. **Conclusions**: Partial support for the CaR-FA-X model was found for child and adolescent populations. Recommendations, proposals for future research, and plausible explanations for the mixed findings are discussed.

Keywords: Overgeneral autobiographical memory; Autobiographical memory specificity, CaR-FA-X model; Children and adolescents

Introduction

Autobiographical memory (AM) is a memory storage system responsible for past episodic memories and self-related semantic information (Conway & Pleydell-Pearce, 2000). The self-memory model of AM (Conway & Pleydell-Pearce, 2000) posits that there are three levels of memory representations held within a hierarchical structure of the AM storage base. These levels range from the highest, broadest level of memory representation for prolonged periods of time, to general memory representations for single and repeated general events to event specific memory representations. The structure of AM forms a broad, cohesive life story of past personal memories. It is largely accepted that AM is crucial for human functioning (Conway & Pleydell-Pearce, 2000; Nelson & Fivush, 2004). For example, AM recall can serve as an aid in problem solving and shaping opinions and attitudes (Cohen, 1989). Moreover, the ability to recall specific memories from past events allows the guidance of present and future thoughts and behaviours as well as the regulation of emotions (Raes, Hermans, de Decker, Eelen, & Williams, 2003). A specific autobiographical memory is a memory of a personally experienced event that occurred at a particular time and place, which lasted less than a day. For example, a mother's memory of taking her child to school on their first day would be deemed as a specific memory. Remembering events however, in a non-specific, generalised way refers to the phenomenon of overgeneral autobiographical memory (OGM), sometimes denoted as reduced autobiographical memory specificity (rAMS[1]). Categorical and extended memories are forms of OGM. Categorical memories are defined as memories for categories of events (e.g. every Saturday night) and extended memories are

[1] Across studies, the terms overgeneral memory and reduced memory specificity are used interchangeably. Given the nature of scoring on autobiographical memory tests, overgeneral or specific memories are typically analysed. OGM refers to memories that no not contain specific details (e.g., categorical and/or extended), and rAMS refers to memories with limited amount of specific detail. See Griffith et al. (2012) for a review on methodological issues with the measurement of OGM (and rAMS).

defined as general events that last over an extended time frame (e.g. my summer holiday in Florida).

The phenomenon of OGM has been widely investigated since first observed in a sample of suicidal adults (Williams & Broadbent, 1986). Since then, OGM has been associated with major depressive disorder (MDD; Sumner, Griffith, & Mineka, 2010; Williams et al., 2007) and post-traumatic stress disorder (PTSD; Kleim & Ehlers, 2008; Sutherland & Bryant, 2008) in adults. OGM is also indicative of a stable characteristic in adults recovered from depression (Mackinger, Pachinger, Leibetseder, & Fartacek, 2000). Given the clinical significance of OGM, researchers have begun to focus attention towards a greater understand of the theoretical underpinnings of OGM.

Theoretical models of AM propose that AM's can be recalled in two ways, either through a generative process or by direct retrieval (The self-memory model; Conway & Pleydell-Pearce, 2000). Generative retrieval refers to top-down processing spreading down through the autobiographical memory knowledge base, activating broad, to general and then to event specific memories in the hierarchy whereas direct retrieval occurs when an environmental cue activates an immediate event specific knowledge. Conway and Pleydell-Pearce (2000) propose that OGM's are retrieved when the search for a specific memory is truncated early in the search, at a higher broader, general level of representation. The authors call this 'dysfacilitation'. According to Conway and Pleydell-Pearce (2000), dysfacilitation occurs as a passive way of avoiding sensory-perceptual elements specific memories thought to be encoded at the time of the memory event[2]. For example, when a search for a specific memory elicits the sensory-perceptual information associated with a traumatic event, this

[2] Conway and Pleydell-Pearce (2000) also suggests that OGM could occur from a lack of encoding, rather than processing at retrieval. The later view has been disputed however as experimental manipulations have shown to improve memory specificity which would be difficult to do if the representation was not stored at encoding (see Williams et al., 2007 for a review).

results in a passive avoidance and an OGM is retrieved. This account of OGM is similar to Williams (1996) affect regulation theory, which proposes that traumatised children adopt an overgeneral memory style as a way to avoid negative affect associated with specific memories. That is, children exposed to trauma will truncate a search for a specific memory at an intermediate (i.e. general level) description as a strategy to avoid negative affect. Remaining at a general level of the search hierarchy to reduce negative affect has been termed 'functional avoidance' (Williams et al., 2007).

Both the self-memory model (Conway & Pleydell-Pearce, 2000) and the affect regulation theory (William, 1996) highlight the importance of exposure to traumatic events on AM, specifically that OGM develops due to avoidance of negative affect or the sensory-perceptual elements of specific memories for traumatic events. While these theories propose functional avoidance as a key element of OGM, they do not account for OGM in individuals who have not been exposed to trauma. The models also do not take account that in trauma exposed populations, the truncating of the search strategy at a general level of description (i.e. resulting in an OGM) may occur through different mechanisms rather than as a way of avoiding negative affect. Williams and colleagues now recognise that a number of mechanisms can contribute to OGM, in trauma and non-trauma exposed populations (The CaR-FA-X model; Williams et a., 2007).

The CaR-FA-X model (Williams et al., 2007)

The CaR-FA-X model is based on the foundations of Conway and Pleydell-Pearce's (2000) self-memory model. It was developed as a framework to enhance understanding of OGM in adults (Williams et al., 2007). This model (see Figure 1) proposes three mechanisms that can disrupt the generative retrieval processes, in isolation, or in interaction and provides a theoretical framework for the mechanisms associated with OGM in populations not only specific to those exposed to trauma. The CaR-FA-X mechanisms are; *c*apture and *r*umination

(CaR), *f*unctional *a*voidance (FA) and impaired e*x*ecutive control (X).

[*Insert Figure 1 here*]

Functional avoidance

The functional avoidance mechanism of the CaR-FA-X model is similar to the self-memory model (Conway & Pleydell-Pearce, 2000) and the affect regulation model (Williams, 1996) accounts of OGM. This mechanism refers to the ability to remain at a general level of retrieval as a way of affect control as the recollection of general descriptions result in less affect in comparison to the retrieval of specific memories. The activation of specific emotional memories can result in numerous strategies using top-down control processes in an attempt to avoid emotional responses from these specific memories. Therefore, remaining at a general level of retrieval can act as a strategy to avoid negative affect.

Williams et al. (2007) builds on previous models of 'avoidance' and suggests that functional avoidance can generalise to other types of memories too, not only for memories associated with a specific trauma. For example, individuals who have been exposed to a traumatic event are more probable to retrieve an OGM, even to neutrally valenced events as they have likely discovered that the retrieval of specific memories can result in negative consequences (e.g. negative affect). Functional avoidance can therefore be negatively reinforced. The authors further propose that avoidance, as a way of managing affect, can take time to develop and in some individuals such a strategy may be flexible or helpful in some situations but for others it can become inflexible, and a habitual response.

Capture and rumination

The capture and rumination mechanism of the CaR-FA-X model posits that capture errors can result from a disruption of the retrieval process if conceptual abstract information activated at an early stage is self-relevant or related to self-representations. Conceptual

processing based on self-representations is predominant in the early stages of retrieval (Conway, Singer, & Tagini, 2004; Williams et al., 2007) and subsequently the search for a memory passes across the knowledge base rather than down the hierarchy (Sumner, 2012), resulting in an OGM. If continued attempts are terminated at this general stage, these 'intermediate descriptions' will become elaborated and future attempts will likely activate conceptual information, which activates other intermediate self-representations rather than specific memories. This process is referred to as mnemonic interlock (Williams et al., 2007). Capture errors can also result from a discrepancy between high and low discrepant cue words.

Cue words on the autobiographical memory test (AMT, Williams & Broadbent, 1986) can bring about discrepancies between a person's current state and their desired state. When there is a state of self-discrepancy, there is a change in processing to more general conceptual way of processing information. This is conducted as a method to maintain self-coherence (Conway & Pleydell-Pearce, 2000). Thus, a person can become captured at this early stage of retrieval, causing the search to become abandoned and an overgeneral memory to be recalled (Williams et al., 2007). This method as a way to resolve self-coherence between an individual's current and ideal state is particularly salient in individuals prone to rumination given that repetitive thought in rumination is thought to be driven partly by the discrepancy between intended goals and current state (see Watkins, 2008 for a review).

Rumination, the perpetual and persistent focus of attention towards negative thoughts, depressive affect and their consequences (Nolen-Hoeksema, 1991), can elaborate the conceptual, abstract information which is activated in the early search for a specific memory. This focus on general representations at this early stage of retrieval increases the probability of attention becoming captured, in turn the search becomes truncated subsequently resulting in OGM. Although the CaR-FA-X model does not differentiate between the different aspects

of rumination (Treynor, Gonzalez, & Nolen-Hoeksema, 2003), in the adult literature, brooding rumination (the passive focus on negative and self-blaming thoughts) but not reflection (the non-judgemental attentional focus on problem solving) has been shown to mediate the relationship between symptoms of depression and OGM (Debeer, Raes, & Hermans, 2009).

Impaired executive control

Impaired executive control is the third mechanism of the CaR-FA-X model. Executive control (sometimes referred to as cognitive control or executive functions, see Diamond, 2013) is a broad term which refers to the ability to flexibly and efficiently coordinate a set of cognitive processes responsible for the planning, initiation and monitoring of complex goal directed behaviour (Dalgleish et al., 2007; Roberts, 1998; Shah & Miyake, 1999; Williams et al., 2007). There is a continuing effort to clarify the nature, components and definition of executive control (Diamond, 2013) but despite much debate, theoretical advancements have proposed that there are three main separable, but related executive functions: inhibition, working memory updating and switching (Miyake et al., 2000). A recent review paper on executive functions highlighted that higher order executive functions, such as planning, problem solving and reasoning skills, are built upon these initial executive functions (Diamond, 2013). The search for a specific memory relies on executive resources and deficits in executive control can hamper a search strategy for a specific memory at different levels of retrieval, resulting in OGM. For example, impairment in working memory capacity can reduce the ability to hold and update retrieved information in working memory, while impaired inhibitory processing may allow irrelevant autobiographical material to enter the search, in turn capturing attention and truncating the search (Conway & Pleydell-Pearce, 2000; Williams et al., 2007).

Multiple mechanisms

The Car-FA-X model (Williams et al., 2007) posits that the three mechanisms (capture and rumination, functional avoidance and impairment in executive control) can work in isolation or in interaction. For example, impairments in executive control can hamper the search strategy and cause a person to become 'captured' at this early stage of retrieval. Furthermore, the ability to inhibit irrelevant information will be particularly difficult if a person has a tendency to ruminate. It is evident that there is great overlap between mechanisms yet there is a great predominance within the literature to investigate only one mechanism of the CaR-FA-X model.

Aims and objectives

This review aims to systematically evaluate the role of trauma exposure on OGM and the three mechanisms of the CaR-FA-X model in child and adolescent, clinical and non-clinical populations. We therefore investigated whether trauma exposure is related to OGM and whether the mechanisms of the CaR-FA-X model can account for OGM in child and adolescent, trauma exposed and non-trauma exposed populations.

While research with predominately adult populations do tend to support the role of trauma on OGM and CaR-FA-X model mechanisms (see Sumner, 2012) it is important for research not only to provide evidence for OGM in adulthood but also to examine the way in which memory specificity, or overgenerality, develops and differs across age (see Valentino, 2011 for a developmental overview of OGM). For example, OGM has been reported among children who have experienced burns (Stokes, Dritschel, & Bekerian, 2004) but a lack of a relationship has been reported in adult burn victims (Willebrand et al., 2002). These findings suggest that developmentally, the timing of exposure to trauma (i.e. trauma in childhood vs adulthood) or the event itself may be an important factor for OGM which manifests itself differently in childhood and adulthood. It further highlights that drawing conclusions about

the strength of evidence of OGM in children and adolescents based on adult populations may be misleading. Previous researchers have also highlighted this issue (Hitchcock, Nixon, & Weber, 2014a).

Previous vs. current review

Previous reviews on OGM primarily focus on studies which include few child and adolescent populations (Sumner, 2012; Williams et al., 2007). However, two reviews with child and adolescent populations have been published, though each has certain limitations. Valentino (2011) focused on developmental aspects of memory specificity, rather than specifically reviewing the CaR-FA-X model. Hitchcock et al. (2014a) investigated OGM in child psychopathology, with a sub-section (8 studies) on the applicability of the CaR-FA-X model and ten studies separately investigating trauma exposure and OGM. More evidence is now available. The current review investigates 22 studies, within these studies we examine 9 findings for the CaR mechanism (four capture, 5 rumination), two for the FA mechanism and 10 findings for the executive control mechanism. Sixteen findings on the relationship between trauma exposure and OGM are included. This evidence can allow a more nuanced, complex understanding of OGM in young people. For example, we can now review literature which investigates the interacting mechanisms of the CaR-FA-X mechanisms and examine any differences between clinical and non-clinical child and adolescent populations. In this way, the review will provide a greater understanding of the associations and vulnerability to OGM, across different populations (e.g., clinical, non-clinical, trauma exposed), while accounting for symptoms of depression and measurement differences.

OGM measurement

Overgeneral memory has been examined by a multitude of measures within the literature. The gold standard measure is the AMT (Williams & Broadbent, 1986). On the original AMT, participants were presented with 10 cue words (positive and negative), and

asked to retrieve a specific personal memory in response to each cue word with prompts given if a specific memory was not recalled. The AMT today, as described by Williams et al. (2007) asks participants to recall an important or trivial, a recent memory for an event or one from a long time ago to each cue word. Participants are told that the event should be specific, with examples and practice trials provided. The length of time given to respond varies from study to study but typically involves 30 or 60 seconds. Memories are usually coded as specific, or overgeneral (categorical and/or extended memories), with a category for semantic memories and omissions.

The AMT is operationalised differently across studies, with some slight variations as to the number and cue words given, the way in which the cue is delivered, the time limit for responses, and how the measures are scored. For example, some authors opt for using the number of memories for the unit of analysis (Crane et al., 2014), while others opt for the proportion (Brennen et al., 2010). There is also great heterogeneity in the type of memory analysed. Some researchers examine specific memories (Johnson, Greenhoot, Glisky, & McCloskey, 2005) and others opt for analysing overgeneral memories (Kuyken, Howell & Dalgleish, 2006). Griffith et al. (2012) argues that the choice of memory type used in analysis has theoretical consequences. If specific memories are used as the memory type for analysis then effectively extended, categoric and semantic memories recalled are grouped together as overgeneral. Likewise, if overgeneral memories are used (e.g. categoric and/or extended), then sematic memories are grouped together with specific memories. To add further disparity, there is great debate as to whether omissions reflect an overgeneral memory or whether an individual recalled a specific memory but for whatever reason did not want to tell the examiner (see Griffith et al., 2012, for a review).

There are also written versions of the AMT in which participants are asked to write down their memories to the cue words (Raes, Verstraeten, Bijttebier, Vasey, & Dalgleish,

2010), a pre-school version (the AMT-PV; Nuttall, Valentino, Comas, McNeill & Stey, 2014), a constrained version which asks participants to recall memories for events 24 hours post trauma and a minimal instruction versions of the task (Debeer et al., 2009) to name a few. The minimal instruction autobiographical memory test (Mi-AMT; Debeer et al., 2009) omits asking participants for a specific memory and instead asks participants to recall a memory without stating it should be specific and no examples are given. The Mi-AMT has been shown to increase detection of reduced memory specificity in non-clinical populations (Debeer et al., 2009).

In addition to these variations on the AMT, there are a number of other measures that investigate OGM or rAMS such as structured interviews. The Autobiographical Memory Interview (AMI; Kopelman, Wilson, & Baddeley, 1989) is a two-part interview that examines recall of semantic autobiographical information (e.g. personal facts) and specific episodic memories (e.g. specific events recalled from three time periods, childhood, early adult life, and recent events). No cue words are given and scoring derives from the amount of detail provided about the time and place of each event. AM has also been examined with the Family Disagreements Questionnaire (FDQ: Salzinger, Feldman, Hammer, & Rosario, 1992). For example, Orbach, Lamb, Sternberg, Williams, and Dawud-Noursi, (2001) utilised the FDQ to assess autobiographical memory style. The FDQ askes children about child-parent and interparental disagreements and Orbach et al. (2001) coded the types of response utterances as specific utterances, generic/categoric utterances, generic/extended utterances and omissions.

It is not clear within the literature as to which task or scoring method works best but given that OGM has been reported across variations in task design and scoring, this suggests that OGM is a robust phenomenon. In the current review, there is great heterogeneity of the included studies in relation to AM measurement including the unit of measurement, number

and volume of cue words, cue presentation and measurement type (specific vs OGM). Given these different variations of OGM measurement included in the current review, and the theoretical and practical issues discussed, a separate review of AM measurement specifically in child and adolescent populations would add a significant contribution to the literature. The studies reviewed further vary in their scoring algorithms, with some authors analysing the number or proportion of OGM or specific memories, with some opting to analyse omissions as an OGM, while others exclude them. It has been argued that effect sizes from different studies cannot be compared if they are calculated differently (see Griffith et al., 2012; van Vreeswijk & de Wilde, 2004). Given the heterogeneity of the included studies in the current review, we do not provide a meta-analytical synthesis but instead provide a narrative synthesis of the literature.

Methodology

Summary of search strategy

Literature search strategies were developed using medical subject headings (MeSH) and text words related to autobiographical memory in childhood and adolescence. Seven online journal databases 'PsychInfo', 'PsychArticles', 'PubMed', 'Web of Science', 'Medline', 'SCOPUS' and 'Embase' were searched for English-language, peer-reviewed papers, published since Williams and Broadbent's (1986) seminal paper, which investigated, or commented upon, the relationship between trauma exposure and/or one or more of the functions of the CaR-FA-X model and autobiographical memory in childhood or adolescence (mean age <18 years old). We considered studies with some participants above the age of 18 years only when the mean age of the whole sample was 18 years or less. The key words employed included: ('autobiographical memory' OR 'episodic memory' OR 'retrospective memory') AND ('specific' OR 'overgeneral' OR 'over general' OR 'over-general' OR 'categoric' OR 'extended) AND ('child' OR 'adolescent' OR 'youth' OR 'minor' OR 'girl'

OR ‘boy’ OR ‘teen’). The last date searched was January 2016. Reference lists of included studies were examined for any additional relevant studies. The results of the search are summarised in Figure 2.

[*Insert Figure 2*]

Selection, inclusion and exclusion

At stage 1, the initial search returned a total of 1975 results from peer reviewed journals (see Figure 2). From the original search results, 36% were duplicates and thus removed. Titles and abstracts were screened at stage 2 (n = 1266). Inclusion criteria was that studies were retained that examined one of more of the mechanisms of the CaR-FA-X model and/or trauma exposure in children or adolescents (mean age < 18 years old) were retained. Studies were also retained if they investigated one or more of the mechanisms but did not specify the CaR-FA-X model. For example, a paper investigating the effects of rumination on overgeneral memory was retained, even though it did not refer to the model. Clinical and non-clinical samples were included. A sub-sample of 10% of titles and abstracts were independently reviewed by one reviewer at stage 2 (97% agreement). Any discrepancies were resolved through discussion. A majority of these studies (n = 1220) were removed from further analysis as they did not meet criteria. At stage 3, a total of 46 full-text articles were assessed for eligibility (based on the inclusion criteria discussed above). The papers were read in their entirety and scrutinised for relevance. A sub-sample of 10% of full-text papers were independently reviewed by one reviewer at stage 3 (100% agreement). In total, 27 papers were removed from the analysis and the justification for this removal is detailed in Figure 2. Nineteen peer-reviewed papers were identified through this search strategy and deemed eligible for inclusion in the review. One further study was located in reference list checks. Two of the peer-reviewed papers contained two studies within each paper that met the inclusion criteria. The total number of peer-reviewed papers in the current review is 20.

Two papers included two studies in each, and therefore a total of 22 studies were examined in total.

Data extraction and quality assessment

Retained studies were reviewed and relevant data was extracted using an adapted version of data extraction forms based on information from the Cochrane Handbook (Higgins & Green, 2011, see Appendix 1). To ensure consistency across reviewers, 10% of papers were independently screened (93% agreement). An adapted version of the Newcastle-Ottawa scale (NOS) was used to assess of the quality of studies (see Appendix 2). Modified versions of the NOS scale have been used by several other researchers to appropriately assess the quality of cross-sectional studies (Herzog et al., 2013; Patra et al., 2015). A maximum of nine points can be awarded on quality assessment for cohort and case control studies, with a score of seven or more as a cut off to be considered a good quality study (see McPheeters et al. 2012; Patra et al., 2015). A maximum of seven points can be awarded for cross-sectional studies and therefore a score of five or above is considered a good quality study. Due to the heterogeneous nature of the included studies, individual studies were not quality assessed against each other but instead a quality score is provided for descriptive purposes only. Quality assessments were undertaken by the first author and 10% and were screened by an additional reviewer (92% agreement). Conflicts were resolved through a subsequent team discussion.

Reporting

To ensure appropriate reporting and transparency throughout, the Preferred Reporting Items for Systematic reviews and Meta Analyses (PRISMA) statement and guidelines were used to guide the current review (Liberati et al., 2009). An updated version became available during the review (Shamseer et al., 2015) and the review met these guidelines.

Data analysis

The studies identified varied substantially in terms of their study design, tasks used, and scoring procedures applied to outcome measures. Therefore, the summary of data was carried out using narrative synthesis. To ensure a robust and transparent synthesis of the evidence, the narrative synthesis explored the relationship and findings both within and between the included studies, in line with the guidance from the Economic and Social Research Council (ESRC) Methods Programme (Popay et al., 2006, see Figure 3.

[*Inset Figure 3*]

Results

Description of studies included

Twenty two studies were included in the review. Of the 22 peer-reviewed studies, the median number of participants per study was 82 (range 24-5792). The age of the participants was 4 to 20 years with a median age of 14.60 years. Twenty one of the peer reviewed studies provided gender information and 43% of the participants were male. Of the 22 studies, six studies recruited a clinical sample and 16 recruited non-clinical populations. Within the 22 studies, sixteen findings which investigated trauma exposure were examined and sixteen findings which examined one or more of the CaR-FA-X mechanisms was examined. Fourteen findings examined one mechanism of the CaR-FA-X model in isolation, two examined two mechanisms and no published study examined all three mechanisms of the CaR-FA-X model. Quality assessment was conducted on 22 studies (see Table 1), and grouped into three categories: cohort, case-control and cross-sectional.

[*Insert Table 1*]

Results have been summarised according to two categories: 1) trauma exposure studies and 2) studies investigating the CaR-FA-X mechanisms. The studies investigating the CaR-FA-X mechanisms have been split by each mechanism (i.e. capture and rumination

studies, functional avoidance studies and impaired executive control studies) and a category with papers that examined interactions between mechanisms. Within each category, a) the role of symptoms of depression, b) clinical status of the participants, c) methodology, d) outcome measures and e) whether the findings constitute a vulnerability to OGM was considered. A summary of findings for the 16 studies investigating trauma exposure and OGM is presented in Table 2 and a summary of the 16 included studies investigating the CaR-FA-X model is presented in Table 3. Outcome measures and variations in measurement task and scoring can be found in Table 4.

[*Insert Table 2*]

[*Insert Table 3*]

[*Insert Table 4*]

Trauma exposure

Sixteen of the studies investigated trauma exposure on OGM (see Table 2). Of the peer-reviewed studies, the number of participants tested was 6857 and the median number of participants per study was 65 (range 24-5792). The age of the participants ranged from six to 20 years with a median age of 14.10 years across the sixteen studies. Of the sixteen studies, fifteen provided information on gender. Male participants accounted for 45% of the sample. Of the sixteen studies, all except one (Arie, Apter, Orbach, Yefet, & Zalzman, 2008) included a Criterion A stressor event required for the DSM–V for posttraumatic stress disorder (American Psychiatric Association, 2013). A Criterion A event is defined as exposure to actual or threatened death, serious injury, or sexual violence. This can include direct experience or witness to an event, learning about the event (e.g. occurred to family member or friend) or repeated or extreme exposure to aversive details of events (e.g. police officers repeatedly exposed to details of child abuse).

A positive main effect of trauma and OGM or rAMS was found in 10 studies (Arie et

al., 2008; Brennen et al., 2010; Crane et al., 2014; Neshat Doost et al., 2014; Ogle et al., 2013; Stokes et al., 2004; de Decker, Hermans, Raes, & Eelen, 2003; Nixon et al., 2013, study 2; Meesters et al., 2000; Valentino, Toth & Cicchetti, 2009) and while one study (Valentino, Bridgett, Hayden & Nuttall, 2012) found no main effect they did report an interaction with symptoms of depression. Valentino et al. (2012) found that when symptoms of depression were low, an abused group of children and adolescents retrieved more OGM's than a non-abused group. At higher levels of symptoms of depression however, the non-abused group retrieved more OGM's than the abused group. It should be noted that although Nixon, Ball, Sterk, Best and Beatty, (2013, study 2) found an association between trauma exposure and rAMS, this was specific to the group with PTSD (and subthreshold PTSD). One study reported a negative effect, such that adolescents with MDD and a history of trauma were less overgeneral than adolescents with MDD and no trauma (Kuyken et al., 2006). Interestingly, when the number of specific memories was used in the analysis, Kuyken et al. (2006) reported that the depressed group who were exposed to trauma reported fewer specific memories than a never-depressed control group with no trauma.

Four studies found no relationship between trauma exposure and OGM or rAMS (Hitchcock, Nixon & Weber, 2014b; Johnson et al., 2005[3]; Nixon et al., 2013, study 1; Orbach et al., 2001). It should be noted that although Nixon et al. (2013, study 1) reported that trauma exposure was not correlated with rAMS they did however find that when constrained to recall memories within 24 hours post trauma, children were more specific. This was only found when the children displayed high levels of acute stress symptoms (as measured via the Child PTSD Symptom Scale; CPSS; Foa, Johnson, Feeny, & Treadwell, 2001) in comparison to children scoring low or the control group. When the children were not

[3] Johnson et al. (2005) reported a finding that was approaching significance ($p = 0.06$) positing that recent family violence was associated with OGM (for neutral cues only). This finding was non-significant when specific memories were analysed.

constrained (i.e. could provide memories for anytime, in line with typical AM tasks) there were no group differences.

Controlling for depressive symptoms

Of the eleven studies supporting the role of trauma exposure on OGM, nine accounted for the role of depressive symptoms. Five studies controlled for symptoms of depression in their analysis (Crane et al., 2014; de Decker et al., 2003; Meesters et al., 2000; Ogle et al., 2013; Valentino et al., 2009) and four studies reported no difference between groups in symptoms of depression or confirmed that OGM was not associated with symptoms of depression (Brennen et al., 2010; Neshat Doost et al., 2014; Nixon et al., study 2; Stokes et al., 2004). It should be noted that Crane and colleagues excluded children with probable depression at ages 7.5 and 10.5 years and this did not alter results; however, after controlling for symptoms of depression at aged 12.10 years, results were non-significant (although remained significant when data imputation was used). Arie et al. (2008) did not control for symptoms of depression but the suicide measure in their study included items that correlated with depression. Given that the suicidal group scored higher on this measure the possibility that the symptoms of depression may have accounted for the association between negative life events and greater overgeneral memory recall in the suicidal group cannot be ruled out. As nine of the 11 significant studies accounted for symptoms of depression, it is unlikely that the relationship between trauma exposure and memory specificity is due to symptoms of depression. Nonetheless, future research that investigates the role of symptoms of depression on the OGM and trauma relationship would be fruitful given that some research has suggested that symptoms of depression moderated the relationship between trauma and OGM (Valentino et al., 2012).

Clinical status comparisons

Of the studies supporting a relationship between trauma exposure and increased OGM, four included clinical populations (Arie et al., 2008; de Decker et al., 2003; Nixon et al., 2013, study 2; Valentino et al., 2012) and the remaining studies recruited non-clinical participants from a diverse range of sources (see Table 2). These findings suggest that the effect of trauma on OGM or rAMS is not an artefact of clinical disorder as it is reported in both clinical and a range of non-clinical samples.

Explained by heightened symptoms of PTSD?

Of the studies that show a relationship between trauma exposure and increased OGM, three demonstrated that symptoms of PTSD were not related to OGM (Brennen et al., 2010; de Decker et al., 2003; Neshat Doost et al., 2014) and one study indicated no group differences in PTSD symptoms overall (Stokes et al., 2004). Valentino et al. (2012) reported that controlling for a diagnosis of PTSD did not change the finding of an interaction between abuse and depressive symptoms on OGM. Crane et al. (2014) assessed probable PTSD and, as only one participant scored above a clinical cut off, they did not further consider the role of PTSD. Meesters et al. (2000) did not investigate symptoms of PTSD. Overall, five studies showed that symptoms of PTSD do not account for the relationship between trauma exposure and OGM or rAMS. One study however refutes this view and suggest that PTSD could account for the relationship between trauma exposure and OGM. Nixon et al. (2013, study 2) reported that trauma exposed children with PTSD retrieved fewer specific memories in comparison to a trauma exposed non-PTSD control group. This finding suggests that it is PTSD which is associated with OGM and not trauma exposure per se. While Ogle et al. (2013) did not report findings on the relationship between PTSD and memory specificity in their adolescent sample only, they did note that heightened levels of PTSD was associated with memory specificity in a mixed adolescent and adult sample who reported childhood sexual abuse as their most traumatic life event. These findings however are in contrast to

Kuyken et al. (2006) who found that adolescents with probable PTSD reported *less* OGM than those without a probable diagnosis of PTSD.

Nixon et al. (2013, study 1) reported that when constrained to recall memories from within 24 hours post trauma, children with high levels of acute stress symptoms were more specific than children scoring low, or those with no symptoms. Similarly, Hitchcock et al. (2014b) reported that time since exposure to trauma moderated the relationship between OGM and symptoms of PTSD. The authors noted that at six months' post trauma, OGM was protective against PTSD symptoms. The findings of Hitchcock et al. (2014b) suggest that OGM is not associated with a negative outcome (i.e. PTSD symptoms) soon after trauma. Taken together, these findings show that the effect of symptoms of PTSD on the relationship between trauma history and OGM is mixed. It has been shown that having a trauma history is associated with OGM in the absence of symptoms of PTSD, while others demonstrated that the trauma and OGM relationship was only found in a trauma group experiencing PTSD. It has also been shown that trauma exposed adolescents with symptoms of PTDS were more specific in their memory recall, and that the time since trauma may be an important moderator of OGM and PTSD. It is evident that further, well controlled studies are needed to better establish the role of symptoms of PTSD in the relationship between trauma exposure and OGM.

Type of trauma and trauma measurement

The type of trauma could be a potential moderating factor in the relationship between trauma history and OGM. While Arie et al. (2008), Brennen et al. (2010), Meesters et al., 2000, Neshat Doost et al. (2014), Nixon et al. (2013) study 2, and Stokes et al. (2004) did not examine the differences between different types of trauma exposure on memory specificity, Crane et al. (2014), de Decker et al. (2003), Ogle et al. (2013) and Valentino et al. (2009) provide information on different types of trauma. Valentino et al. (2009) proposed that certain

memories such as sexual or physical abuse may elicit more distressing emotions and therefore result in greater OGM. The authors reported that abused (sexual & physical) children demonstrated greater OGM than neglected children or non-maltreated children. It should be noted that neglect, rather than relating to a specific incident, can be operationalised as a chronic omission of basic caregiving and therefore neglected children may not show OGM as there is no specific traumatic memory to avoid.

Crane et al. followed a cohort of children from toddlers (up to approximately two years nine months in age) to middle childhood (from five years up to approximately 11 years, two months). They noted that adolescents assessed at aged 13 who had experienced a severe trauma (defined as child removed from family, physical or sexual abuse) in middle childhood (from five years up to approximately 11 years, two months) were at a 60% increased risk of rAMS. Interestingly, the authors reported that exposure to moderate traumatic events (defined as having an ill mother, homelessness, mother and/or partner emotionally cruel to children) in middle childhood was associated with less OGM when assessed at aged 13, relative to participants with no exposures. The findings of Crane et al. (2014) suggest that it is severe traumas that are particularly associated with OGM, however the specific type of trauma that is related to OGM remains unclear. de Decker et al. (2003) helped to provide further analysis on the effect of different types of trauma exposure on rAMS. While the authors noted evidence for a negative relationship between memory specificity and a total composed trauma score, further analysis of their data suggests that emotional, physical, and sexual abuse was specifically correlated with rAMS. Emotional neglect and sexual approach were not correlated with rAMS in their study.

Ogle et al. (2013) investigated the effect of childhood sexual abuse (CSA) on memory specificity. They reported that adolescents without a history of CSA reported more specific memories than adolescents with CSA histories. However, their results did not generalise

when they examined severity when combining a history of CSA, physical abuse and neglect. The findings of Ogle et al. (2013) suggest that the link between trauma and OGM is specific to CSA. Taken together, findings suggest that emotional, sexual and physical abuse, childhood sexual abuse, and severe exposures to trauma are associated with OGM, relative to neglect, moderate exposures, emotional neglect, sexual approach and CSA, physical abuse and neglect combined.

Despite these promising advances, the literature with child and adolescent populations has produced mixed findings. For example, while war exposure, sexual, emotional and physical abuse, as well as negative life events have been associated with OGM and rAMS (Arie et al., 2008; Brennen et al., 2010; Ogle et al., 2013; de Decker et al., 2003; Meesters et al., 2000; Valentino et al., 2012), other studies included in the review have found no such support for similar events (Hitchcock et al., 2014b; Johnson et al., 2005). It does not seem as though the type of trauma can account for differing findings in the current review. It should be noted however, that the majority of abuse victims experience more than one subtype of maltreatment (i.e., high subtype comorbidity) which makes it increasingly difficult to determine how any one specific form of abuse may be uniquely related to OGM. Given the heterogeneous samples, methodology and measurement of trauma exposure and OGM included in the current review, it is evident that further research to clarify the nature of the type of trauma on OGM is needed.

The measurement of trauma exposure varied across the included studies. Typically, within the wider literature there is reliance on self-report measures of trauma and retrospective reports have been subject to criticism in the literature (see Hardt & Rutter, 2004). While some of the included studies relied on retrospective self-report or parental reports (Arie et al., 2008; Crane et al., 2014; de Decker et al., 2003; Hitchcock et al., 2014b) not all research studies relied on self-report alone. Some verified self-reported trauma via

neuropsychologists (Brennen et al., 2010), parental reports (Stokes et al., 2004), and information from social workers, parents and children's reports (Orbach et al., 2001). Others measured trauma from interviews (Johnson et al., 2005), interviews with parents (Nixon et al., 2013, study 1) or with questionnaires and clinical interviews (Kuyken et al., 2006). Documented cases of trauma from school records (Neshat Doost et al., 2014), youth care records (Meesters et al., 2000), therapy groups (Nixon et al., 2013, study 2), records held in child maltreatment diagnostic and treatment centres (Ogle et al., 2013) and child protective and preventive records (Valentino et al., 2009; Valentino et al., 2012) were used in the remaining studies. The relationship between trauma exposure and OGM does not seem to be an artefact of the trauma measure as the relationship was found across different levels of measurement.

Vulnerability to OGM

Little is known developmentally about how, why or when OGM develops after trauma exposure and prospective studies are warranted to highlight when and the way in which exposure leads to OGM. Three studies were able to longitudinally document trauma exposure throughout childhood, allowing for a proximal measure of exposure (Crane et al., 2014, Johnson et al., 2005; Orbach et al., 2001), but only Crane et al. (2014) found an association between trauma exposure and rAMS. The findings of Crane et al. (2014) suggest that trauma exposure in middle childhood, in comparison to early life, was more strongly associated with OGM. Although these findings are valuable, the measure of OGM was not administered at each testing session (i.e. OGM was not assessed in early or middle childhood but only administered when the child was an adolescent at aged 13). It is therefore possible that trauma exposure in early life would have resulted in OGM at the time but any effect was diminished given the time lapse (over 10 years). While not a prospective design, Arie et al. (2008) provides support that a trauma history in middle childhood may be particularly

detrimental to OGM. Arie et al. (2008) in a retrospective study noted that it was negative life events in childhood (less than 12 years of age) that was related to OGM. Negative life events after the age of 12 were not associated with OGM. Taken together, these finding suggest that exposure to trauma in middle childhood may be of particular importance. Future research that examines AMT performance and trauma exposure throughout childhood would be helpful in permitting a greater understanding of OGM.

Variations in tests of OGM

AM measurement across studies can be found in Table 4. The relationship between trauma exposure and OGM was reported across various tests of AM. For example, Meesters et al. (2000) applied the semantic autobiographical memory task (SAMT). Questions on the SAMT focussed on self-referent semantic information personal facts such as previous addresses or names of childhood friends. Despite not directly examining AM in typical format, Meesters and colleagues found adolescents with a history of trauma experienced greater difficulty in recalling autobiographical facts than the adolescents without such a history. It is possible that the traditional AMT methods were not sensitive enough to detect a relationship in non-clinical populations (Debeer et al., 2009) and could serve as an explanation for some null findings. While this may form a reason for null findings in some studies (Hitchcock et al., 2014b) it does not explain null findings (and reverse effects; Kuyken et al., 2006) in the remaining studies. These findings show that trauma exposure is related to OGM across different types of measurement and therefore it is unlikely that the relationship is due to the AMT measure.

The majority of studies within this review have shown demonstrable support for the association between OGM (or rAMS) and trauma exposure in childhood and adolescence. While these studies may explain OGM in trauma exposed populations they do not provide any information on the mechanisms for which trauma exposure may lead to OGM. For

example, Conway and Pleydell-Pearce (2000) and Williams (1996) suggest that trauma exposure results in OGM through functional avoidance as a way of affect regulation. However only two of the reviewed studies that investigated exposure to trauma also examined the effect of functional avoidance (discussed next). Trauma exposure as a pre-requisite of OGM also does not explain how OGM develops in non-trauma exposed populations. The next section of the review aims to evaluate the CaR-FA-X mechanisms in child and adolescent populations. Specifically, we examine the functional avoidance mechanism of the model in trauma exposed populations and then the capture and rumination and impaired executive control mechanisms more generally and not specific to trauma exposed populations.

Functional avoidance mechanism

Two studies directly investigated the functional avoidance mechanism of the CaR-FA-X model. Of the functional avoidance published studies, the number of participants tested was 86 (range 24-62). The age of the participants ranged from 11-18 years with a median age of 15.80 years. Male participants accounted for 14% of the sample. Avoidance was measured using the avoidance subscale of the impact event scale (Horowitz, Wilner, & Alvarez, 1979), and the avoidance subscale of the children's Impact of Event Scale (Smith et al., 2003; Yule et al., 1994).

One of the two studies supported an association between avoidance and OGM (Stokes et al., 2004). The authors compared a group of adolescents who had been admitted to hospital due to a burn injury between the ages of 6 weeks and 14 years old with a control group of adolescents who had received orthodontic dental work. In the burn group, reduced specificity was correlated with higher avoidance, supporting the FA mechanism of the CaR-FA-X model. It should be noted however, that it is possible that reduced specificity could also be attributed to the exposure of the trauma disrupting normal autobiographical memory

development, rather than functional avoidance per se. Contradicting the CaR-FA-X model, Kuyken et al. (2006) found avoidance was associated with reduced levels of OGM (in a clinically depressed plus trauma exposed participant group). As only two studies have examined functional avoidance in children and adolescents it would be erroneous to draw conclusions on the contribution of clinical status, design, vulnerability to OGM or AMT methodology. It is evident that more research is needed to directly test functional avoidance and its relationship with OGM.

Capture and rumination mechanism

Six studies in total investigated the capture and rumination mechanism. The number of participants tested was 771 and the median number of participants per study was 125 (range 50-192). The age of the participants ranged from 7 to 20 years with a median age of 14.14 years. All six studies provided gender information and 47% of the participants were male. Of the six studies, one examined the capture aspect without rumination (Valentino et al., 2009), two examined rumination without the capture aspect (Hitchcock et al., 2014b; Park et al., 2004) and three studies investigated both capture and rumination (Schoofs, Hermans & Raes, 2012, study 1 & 2; Smets, Griffith, Wessel, Walschaerts & Raes, 2013). Capture was assessed by various methods including the use of high and low discrepant cue words (Schoofs et al., 2012, study 1 & 2), a self-discrepancy induction (Smets et al., 2013) and by examining negative self-representations (Valentino et al., 2009). Rumination was assessed by the ruminative response scale (RRS; Treynor et al., 2003) in three studies (Schoofs et al., 2012, study 1 & 2; Smets et al., 2013), attentional manipulation tasks (Park et al., 2004) and the children's response style scale (Ziegert & Kistner, 2002) in another (Hitchcock et al., 2014b). Only two of the published studies examined rumination by its subcomponents of brooding rumination and reflective pondering (Schoofs et al., 2012, study 1 & 2).

A positive main effect was found between capture errors and OGM or rAMS in three of

the four studies (Schoofs et al., 2012, study 1 & 2; Valentino et al., 2009) and while one study (Smets et al., 2013) found no main effect they did report an interaction with symptoms of depression. Smets et al. (2013) reported that greater symptoms of depression were related to increases in OGM and decreases in memory specificity following a self-discrepancy induction, which suggests that symptoms of depression moderate the relationship between capture and OGM. Schoofs et al. (2012, study 1 & 2) examined the capture aspect with non-clinical community adolescents. High and low discrepant cue words were used in the AMT (discrepancy between attributes of the actual and the ideal self) as a method of assessing the capture aspect. A greater proportion of categoric and a reduced proportion of specific memories were retrieved in response to high discrepant cues, in comparison to low discrepant words. Thus, when cues were not consistent with the adolescents' self-image this resulted in capture errors and reduced specificity and greater OGM. To account for the possibility that the findings were reflective of the importance of the cue to the adolescent, rather than the discrepancy per se, the second study of Schoofs et al. (2012) controlled for the effects of cue word importance and confirmed that the results could not be due to the importance of the cue to self-image. In a subsample of participants (abused and control adolescents), Valentino et al. (2009) found negative self-representations were related to OGM, providing support for the capture aspect of the capture and rumination mechanism of the CaR-FA-X model.

The rumination aspect was supported in one of five studies (Park et al., 2004). The authors examined OGM pre and post an experimental rumination and distraction manipulation task. In a sample of adolescents diagnosed with MDD, partially remitted MDD, a psychiatric control and a community control group it was found that rumination (but not distraction) increased OGM, but only within the MDD group (full and partially remitted). The increase in OGM due to rumination was specific to negative cue words and was independent of mood, age, gender or IQ.

Controlling for depressive symptoms

Of the four studies with significant effects, three accounted for symptoms of depression and/or mood (Park et al., 2004; Schoofs et al., 2012, study 1 & 2). Schoofs et al. (2012) entered depression scores as a covariate in their analyses and Park et al. (2004) reported that correlations between depression scores and changes in OGM with induced rumination were non-significant. The findings of Park et al. (2004) suggest that the increase in OGM in the MDD group was not due to changes in mood caused by the rumination induction. Valentino et al. (2009) did not control for symptoms of depression when investigating negative-self representations, although the authors did note that self-reported symptoms of depression were in the subclinical range. Similarly, while Smets et al. (2013) did not find a main effect of capture and rumination on OGM, they did note that symptoms of depression moderated the relationship between capture and OGM Taken together, these findings suggest that the role of symptoms of depression on the relationship between capture and rumination is not clear. Symptoms of depression moderate the relationship between capture and OGM in some studies, yet in others controlling for symptoms of depression does not alter the association between capture and OGM. Further research is needed to examine the role of depression in the OGM and capture and rumination relationship.

Clinical status comparisons

Capture errors were reported in a community sample of adolescents (Smets et al., 2012) who were not currently experiencing a major depressive episode (Scoofs et al., 2012, study 1 & 2) and a sample of adolescents with a history of abuse (Valentino et al., 2009). These findings suggest that capture errors are not simply a function of clinical disorder but are also found in samples with a trauma history and in community populations who are not currently depressed. The only study to find an association between rumination and OGM comprised a clinically depressed sample (Park et al., 2004), which suggests that the

association between rumination, in isolation, and memory specificity may be specific to clinical MDD. Future research is needed to verify this finding.

Vulnerability to OGM

To determine if the capture and rumination mechanism is an underlying vulnerability factor for OGM, longitudinal studies are needed. From the six studies that investigated this mechanism in childhood and adolescence, one study made use of such a design. However, rumination did not predict OGM over time (Hitchcock et al., 2014b).

Variations in tests of OGM

The unit of measurement, number and volume of cue words, cue presentation and measurement type (specific vs OGM) impacts on AMT performance (Griffith et al., 2012; van Vreeswijk & de Wilde, 2004). Given that capture errors were associated with OGM and rAMS across variations in task design and scoring (see Table 4), this suggests that the capture errors and OGM relationship is robust. However, given the limited research with child and adolescent populations, future research is needed to verify this finding. Similarly, given that rumination was non-significant (with the exception of Park et al., 2004) across different versions of the AMT (original AMT, written AMT and Mi-AMT), it is unlikely that null findings of a relationship between rumination and OGM are attributable to the measurement of AM.

Impaired executive control

Ten of the included studies produced results for the impaired executive control mechanism of the CaR-FA-X model. Of the ten studies, the number of participants tested was 845 and the median number of participants per study was 65 (range 27-227). The age of the participants ranged from 4 to 20 years with a median age of 13.38 years across the studies. Of the ten studies, all provided information on gender. Male participants accounted for 46% of the sample. In the current review, inhibition was investigated in four studies (Hitchcock et al.,

2014b; Nuttall et al., 2014; Raes et al., 2010; Valentino et al., 2012), switching ability in one (Valentino et al., 2012), working memory capacity in six (de Decker et al., 2003; Hitchcock et al., 2014b; Johnson et al., 2005; Meesters et al., 2001; Nixon et al., 2013; study 1 & 2), working memory monitoring and updating in one (Hitchcock et al., 2014b) and verbal fluency was investigated in three studies (Kuyken et al., 2006; Hitchcock et al., 2014b; Valentino et al., 2012).

Inhibition

Only one of the four studies that investigated links between inhibitory control and OGM reported a significant result. Raes et al. (2010) found a relationship between greater OGM and reduced behavioural inhibition. Furthermore, Raes and colleagues indicated that reductions in inhibitory control partially mediated the link between symptoms of depression and OGM, which suggests that the link between depression and OGM, at least in part, is due to reduced inhibitory processing. Behavioural inhibition, however, as measured using the colour-word interference task and the day/night task were not associated with OGM (Nuttall et al., 2014; Valentino et al., 2012). Similarly, behavioural inhibition as measured by the "walk, don't walk" subtest of the test of Everyday Attention for Children (Manly et al., 2001) was not associated with OGM (Hitchcock et al., 2014b). While the CaR-FA-X model does not differentiate between types of inhibitory control, Williams et al. (2007) does suggest that the ability to navigate the search hierarchy requires the inhibition of other information within the memory hierarchy. It could therefore be that it is cognitive inhibition (the ability to inhibit prepotent mental representation including thoughts and memories) that is necessary for a successful search for a specific memory. This could explain the null findings reported with behavioural measures of inhibition, although this would not explain Raes et al. (2010) finding. It is important to note that Raes et al. (2010) was the only study to measure inhibition using parental self-report and the authors also excluded some items from the inhibition scale

(the Early Adolescent Temperament Questionnaire) which may have reduced the validity of the scale, and subsequently the reliability of the findings.

Working memory capacity

Of the six studies that investigated working memory capacity and OGM, only two demonstrated a link between working memory capacity and rAMS (Nixon et al., 2013; study 1) or OGM (Hitchcock et al., 2014b). Digit span scores (not errors) on the subtest of the Wechsler Intelligence Scale for Children — 4th Edition (Wechsler, 2003) were positively associated with greater memory specificity (Nixon et al., 2013, study 1). Similarly, Hitchcock et al. (2014b) found that working memory capacity predicted OGM, although this effect was moderated by age. In older children, greater working memory capacity was associated with *less* OGM (as expected) whereas in younger children greater working memory capacity was associated with *greater* OGM recall (not expected). Although difficulty in working memory capacity was not associated with increased OGM (as proposed by the model), greater WMC was associated with less overgenerality. The finding that in younger children greater working memory capacity was associated with *greater* OGM recall refutes the impaired executive control mechanism of the CaR-FA-X model. It should be noted however that greater working memory capacity was not associated with specific memories, only OGM. Hitchcock et al. (2014b) further reported that when levels of inhibition were high, greater working memory capacity and resulted in OGM (contrary to the impaired executive control mechanism of the CaR-FA-X model), but again this interaction was non-significant for specific memories.

Working memory updating

Only one study investigated the relationship between working memory updating and OGM but found no support for the mechanism (Hitchcock et al., 2014b). Employing a computerised n-back task in a trauma exposed sample of children, working memory updating was not found to be associated with OGM.

Verbal fluency

Verbal fluency, the ability to produce as many exclusive words as possible within a semantic category (category fluency) or starting with a specific letter (letter fluency) in a specific time frame, was assessed in three studies (Hitchcock et al., 2014b; Kuyken et al., 2006; Valentino et al., 2012). Only one study found verbal fluency to be associated with OGM. Valentino et al. (2012) recruited 49 adolescent inpatients who were tested on measures of OGM, executive function and were grouped by the presence of absence of previous sexual or physical abuse (findings for trauma reported above). Across the whole sample, category fluency, but not letter fluency, was significantly correlated with OGM. It should be noted that Valentino and colleagues refer to this fluency task as a measure of updating and monitoring of information in working memory.

Switching

Switching ability was examined in one study. Valentino et al. (2012) employed the Wisconsin Card Sorting Test (WCST; Heaton, Chelune, Talley, & Kay, 1993) and reported no associations between switching ability and OGM in their psychiatric inpatient adolescent sample.

Controlling for depression

Of the four studies that reported associations between executive control and OGM only Valentino et al. (2012) controlled for depression in their analyses. The participants in the Hitchcock et al. (2014b) study had no previous diagnoses of depression and, although three of their participant sample scored above clinical cut off on the CDI-S, the authors noted that symptoms of depression were not associated with OGM. Nixon et al. (2013, study 1) reported correlational effects of working memory capacity and rAMS but they did report that symptoms of depression were not correlated with memory specificity. Raes et al. (2010) did not control for symptoms of depression, and reported categoric memories were correlated

with symptoms of depression. The findings of Raes et al. (2010) suggests that the correlation between inhibition and OGM, in part, may be attributed to the effects from symptoms of depression. Indeed, Raes et al. (2010) reported that inhibition was an indirect effect of the relationship between depressed mood and OGM.

Clinical status comparisons

Of the studies showing a relationship between OGM and executive control, one included a clinical sample (Valentino et al., 2012) and three included non-clinical samples (Hitchcock et al., 2014b; Nixon et al., 2013, study 1; Raes et al., 2010). Non-clinical status was as follows: two studies employed trauma exposed participants (Hitchcock et al., 2014; Nixon et al., 2013, study 1) and one study a community sample of children (Raes et al., 2010). The relationship between executive control and OGM was found in clinical, trauma exposed and community samples (see Table 3), suggesting that the relationship is not due to population differences.

Vulnerability to OGM

To determine whether impaired executive control is an underlying vulnerability factor for OGM, longitudinal studies are needed. From the ten studies that investigated this mechanism in childhood and adolescence, three studies made use of such a design (Hitchcock et al., 2014b; Johnson et al., 2005; Nixon et al., 2013, study 1). While Johnson et al. (2005) followed children over time, the authors only tested working memory capacity at the final testing session, providing cross-sectional data for this result. Similarly, Nixon et al. (2013, study 1) tested whether memory specificity predicted later symptoms of PTSD (not included in the current review) and did not test working memory capacity over time. Of the studies reporting significant effects, Hitchcock et al. (2014b) was the only to find a relationship between working memory capacity and OGM over time. Although the authors reported that older children's greater working memory was associated with less OGM, there is a clear need

for longitudinal studies to examine whether impairment in executive control underlies the development of overgeneral memory.

Variations in tests of OGM

AM measurement varied across studies investigating executive control (see Table 4). Some employed different AM tasks and of those that used the AMT there were variations in unit of measurement, number and volume of cue words, cue presentation and measurement type. This may explain conflicting results across the studies. However, while Nixon et al. (2013, study 1) found a link between working memory capacity and rAMS, their second study (Nixon et al., 2013, study 2) which employed the same unit of measurement (number and volume of cue words, cue presentation) and measurement type as their first study, did not find an association between working memory capacity and rAMS. The null findings reported in Nixon et al. (2013, study 2) is therefore unlikely to be due to the version of AMT. However, this does not explain the different findings across the other included studies. Further research is needed to examine the way in which the different versions of the AMT, and different AM tasks may impact research findings on OGM.

Interactions between mechanisms

One of the 22 studies investigated interactions between the mechanisms of the CaR-FA-X model in child and adolescent populations. Hitchcock et al. (2014b) found no interactive effects between rumination and various aspects of executive control (working memory capacity, updating, verbal fluency and inhibition). As only one peer-reviewed study has examined the interacting effects between mechanisms of the CaR-FA-X model in children and adolescents it would be erroneous to draw conclusions on the contribution of clinical status, design, vulnerability to OGM or AMT methodology. More research is needed to examine the interacting effects of the mechanisms of the model.

Discussion

The paper examined the child and adolescent literature on the relationship between exposure to trauma and OGM and examined the applicability of the CaR-FA-X model to identify the contribution researchers have made to our understanding of OGM in such populations. The aim was to ascertain whether or not trauma exposure was associated with OGM in child and adolescent populations and to identify which mechanisms of the CaR-FA-X model were associated with and predictive of OGM in isolation or in interaction. As is often the case in systematic reviews, this process revealed gaps and trends within the literature, and recommendations for future research are offered.

The review findings concluded that a majority of studies supported the role of trauma exposure on OGM (or rAMS). However, while a majority of studies support the role of exposure on OGM, not all studies supported the link. We investigated the role of the type of trauma exposure as a moderator and concluded, similar to Sumner (2012) that there is a lack of consistent support for the type of trauma having an effect on OGM. Echoing findings from Moore and Zoellner (2007) we suggest that further research is warranted before conclusions about the trauma exposure and OGM relationship can be reached. It could be that trauma in interaction with other mechanisms are better able to explain OGM in childhood and adolescence. For example, Williams et al. (2007) suggests that trauma can result in OGM indirectly through impairment in executive control. The authors posit that effortful attempts to control intrusive thoughts relating to the trauma, as well as overriding processing, can result in reduced capacity of executive control. It is clear that there are many pathways in which trauma exposure can lead to OGM, yet little is known under what circumstances the pathways lead to OGM in childhood and adolescence. Developmentally, little is known about how, why or when OGM develops after trauma exposure and whether the age of the child at the time of the trauma has an impact on OGM. While the findings of Crane et al. (2014) were

very valuable as they provided a proximal measure of trauma exposure across childhood, further research is needed.

The literature on functional avoidance specifically was limited. Only two of the studies investigating the role of trauma and OGM examined the functional avoidance aspect of the CaR-FA-X model, one refuting the model and one supporting the model. Future research that examines AMT performance, trauma exposure and avoidance throughout childhood would allow a greater understanding of the developmental aspect of functional avoidance. Such research would also help towards explaining the mechanisms in which exposure to trauma may lead to OGM in some child and adolescent populations but not in others.

The review findings concluded that capture errors were associated with OGM (and rAMS) in child and adolescent populations, both in community populations and in a trauma exposed population (although the trauma exposed was combined with a non-trauma group). Rumination in isolation however, was only associated with OGM in one study with a clinical population. It could be that rumination in isolation is not associated with OGM in non-clinical populations but may be associated with OGM, in the context of greater symptoms of depression. Such findings provide a fruitful avenue for future research on the CaR mechanism. Few studies investigated the different effects of brooding and reflective pondering and those that did reported no differences in the subcomponents of rumination. The literature however has shown brooding rumination and reflective pondering to have differing effects in the literature (Arditte & Joormann, 2011; Burwell & Shirk, 2007; Gibb et al, 2012) and more research is needed to better establish the roles of the subcomponents of rumination on OGM in child and adolescent populations.

The literature on impaired executive control was mixed, and the majority of studies reported null findings. Only two studies supported the relationship between impaired executive control (i.e. inhibition and verbal fluency) and increased OGM, and two studies

found greater working memory capacity to be associated with greater specificity and reduced OGM but did not find impairment to lead to less specificity or increased OGM. There is an array of theoretical issues concerning the measurement of executive control (see Davidson, Amsoa, Cruess, & Diamond, 2006; Diamond, 2013; Miyake et al., 2000) which are beyond the scope of this review but should be considered when examining cognitive functioning in child and adolescent populations. For example, it is debated whether working memory, inhibition and switching are related but separate (Miyake et al., 2000) and whether they rely on and build on each other (Davidson et al., 2006; Diamond, 2013). A review of executive control measures in childhood and adolescence further highlighted the changing, complex processes which underlie performance on executive tasks and suggest that results from such tasks can also be affected by a range of factors such as low applicability to real-life functioning (Hughes & Graham, 2002). These findings highlight multiple issues with the measurement and purity of executive control tasks and could serve as reasons for mixed findings within the review. Tasks that relate to real-life functioning such as processing faces shown as in the internal shift task (De Lissynder et al., 2012) would be advantageous as faces have been shown to be interpersonal and have ecological validity (Joormann & Gotlib, 2006; Raes, Hermans, & Williams, 2006).

Only one published study investigated interactions between mechanisms of the CaR-FA-X model, which reported no interactive effects. More research is needed to provide a comprehensive understanding of interacting effects between the mechanisms of the CaR-FA-X model. Separate research with adolescents highlights a relationship between rumination and executive control, particularly when inhibiting emotional material (Hilt, Leitze, & Pollack, 2014). Williams et al. (2007) does propose that ruminative processing can hinder access to specific memories when executive control is impaired, however no published study has investigated the effect of rumination and impaired executive control for emotional

information on OGM in a child or adolescent population. Williams et al. (2007) also suggested that highly elaborate representations of the self which are accessed early in the search are generally more difficult to inhibit. A fruitful avenue for future research would be to examine the self-relevance of the cues, rumination, and their interactive effects with low executive control, particularly when processing emotional information. Examining these relationships across child development will provide a greater understanding of how the mechanisms of the CaR-FA-X model relate to OGM and further our knowledge of the developmental routes of OGM.

There is considerable heterogeneity between studies in regard to participant sample, age, measures and variables controlled in analyses, making it difficult to confidently draw conclusions. Similarly, few studies investigating the CaR–FA-X model reported statistical power thus increasing the difficulty in understanding whether null findings within the studies are due to problems with low statistical power. Given this variability, the review conclusions must be taken with caution.

Previous vs. current findings

The findings from the current systematic review are in line with previous reviews that support the role of trauma exposure on OGM (Sumner, 2012). While a majority of studies support the role of exposure on OGM, not all studies investigating trauma exposure on OGM supported the link. This is similar to reports by Moore and Zoellner (2007) who noted inconsistent findings of an association between trauma exposure and OGM. These findings are in contrast however to a previous review of the child and adolescent literature who noted that almost all studies supported the role of trauma exposure on OGM (Hitchcock et al., 2014a). While we looked at the role of the type of trauma exposure, we concluded, similar to Sumner (2012) that there is a lack of consistent support for the type of trauma having an effect on OGM. We suggest that further research is warranted before conclusions about the

type of trauma on the trauma exposure and OGM relationship can be conclusively reached. The role of functional avoidance more specifically (i.e. measurement of avoidance rather than trauma exposure) on OGM is less clear in child and adolescent populations to that of adult samples. Sumner's (2012) review and Williams et al. (20007) support the role of functional avoidance whereas the current review reported mixed findings. While there was documented support (albeit some null findings) for the role of trauma exposure on OGM, there was a lack of comparable studies specifically examining avoidance with child and adolescent populations (two studies) to draw conclusions from. This makes it difficult to draw comparisons to previous literature however it does present a possible opportunity for future research.

The findings relating to capture and rumination and impaired executive control emerging from the systematic review differ from previous reports with predominantly adult populations. For example, a recent review of the CaR-FA-X model with predominantly adult studies (Sumner, 2012) found robust support between rumination and impaired executive control on OGM and reported that research findings on capture errors were mixed. In contrast, the current review found no support for rumination in non-clinical child and adolescent populations (only in one clinical population) and reported an association between capture errors and OGM across various task measures and reported in multiple sample populations including non-clinical community samples and adolescents reporting a history of abuse. These findings highlight the importance of not drawing conclusions about child and adolescent populations from studies with adults. Thus, if capture errors and rumination relate to OGM in a different way depending on the clinical status of child and adolescent populations, this has important implications for the design of future research. A recent review of child psychopathology (Hitchcock et al., 2014a), demonstrated that capture and rumination was associated with OGM (although this was based on only two studies).

The role of impaired executive control on OGM appears to differ in child and adolescent studies in comparison to that of adults. Sumner's review (2012) found impaired executive control, especially deficits in inhibition, working memory capacity, the ability to update and maintain information in working memory, and verbal fluency to be associated with OGM, again further highlighting the differences between reviews that include adult populations and those specific to child and adolescent samples. Hitchcock et al. (2014a), like the current review findings, report mixed findings on the executive control mechanisms. We reported a lack of support for inhibition, with only one study in four to report a significant effect (with methodological constraints noted). No study reported reductions in working memory capacity to be associated with OGM (although one study found greater working memory capacity resulted in greater specificity and another reported greater working memory capacity was associated with *less* OGM in older children whereas in younger children greater working memory capacity was associated with *greater* OGM recall). No support for found for switching and OGM but we did find limited support (one in three studies) for verbal fluency and OGM.

Only one study investigated the interacting effects of the mechanisms of the CaR-FA-X model and reported a null effect. No data was available on the interacting effects of the model in previous reviews with child and adolescent populations (Hitchcock et al., 2014a) and therefore current findings cannot be compared. Williams et al. (2007) posits that one mechanism alone is not enough to explain all the OGM data, yet few studies examine multiple components and even less examine interactive effects. The CaR-FA-X model as a whole has not been examined in any published paper with child and adolescent populations. Such findings can only reinforce that future research should address this issue as such work will allow for a holistic understanding of how the CaR-FA-X model can account for OGM. Currently, there are too few studies investigating multiple mechanisms of the CaR-FA-X, and

limited studies investigating the mechanisms of the model over time. There are limited studies investigating the differing effects of the subcomponents of rumination on OGM and no studies evaluating the effect of emotional stimuli in executive tasks. However, these findings highlight a rich opportunity for future research.

At this stage, data from the studies reviewed provided adequate support for the role of trauma exposure on OGM and limited support for the mechanisms of the CaR-FA-X model in child and adolescent populations. Most support for the CaR-FA-X model comes from the capture aspect of the capture and rumination mechanisms, although the lack of studies investigating some mechanisms (i.e. functional avoidance, and some aspects of executive control) should be noted. As OGM research has become more sophisticated, to include investigations of interactive effects between the CaR-FA-X mechanisms, methodological approaches within OGM research in child and adolescent samples should be advanced. Future research would benefit from the investigation of any protective or adaptive factors to OGM. The recommendations for future research presented throughout the review, as well as possible explanations provided for mixed results, will facilitate a greater understanding and refinement of how the CaR-FA-X model can account for OGM in child and adolescent populations.

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Tables and Figures

Table 1: *Quality assessment*

Cohort studies[1]	Selection			Comparability		Outcome			Total
Study	Representativeness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of exposure	Demonstration that the outcome of interest was not present at start of the study	Comparability of cohorts on the basis of design or analysis	Assessment of outcome	Was follow-up long enough for the outcome to occur?	Adequacy of follow up of cohorts	
Crane et al. (2014)	*	*	*		**	*	*	*	8
Hitchcock et al. (2014b)	*	*	*	*	**	*	*	*	9
Johnson et al. (2005)	*	*	*		**	*	*	*	8
Nixon et al. (2013) study 1	*	*	*	*	**	*	*	*	9
Orbach et al. (2001)	*	*	*		*	*	*	*	7
Cross-sectional studies [2]	Selection			Comparability		Outcome			Total
Study	Representativeness of the exposed sample	Non-respondents	Ascertainment of exposure	Comparability of outcome groups on the basis of design or analysis		Assessment of outcome	Statistical test is appropriate		
de decker et al. (2003)	*		*	**			*		5
Nuttall et al. (2014)	*	*	*	*		*	*		6

Park et al. (2004)	*	*	*	**	*	*	7
Raes et al. (2010)	*	*	*		*	*	5
Schoofs et al. (2012) study 1	*	*	*	*		*	5
Schoofs et al. (2012) study 2	*	*	*	*		*	5
Smets et al. (2013)	*		*	*	*	*	5

Case-control studies [3]	selection				Comparability	Exposure			Total
Study	Is the case definition adequate?	Representativeness of the cases	Selection of controls	Definition of controls	Comparability of cases and controls on the basis of design or analysis	Ascertainment of exposure	Same method of ascertainment for cases and controls	Non-response rate	
Arie et al. (2008) [4]	*	*	*	*	*	*	*	*	8
Brennen et al. (2010) study 1	*	*			**	*		*	6
Kuyken et al. (2006)	*	*	*	*	**	*	*	*	9
Meesters et al. (2000)		*	*	*	**		*	*	7
Neshat Doost et al. (2014)	*	*	*	*	**	*	*	*	9
Nixon et al. (2013) study 2	*	*		*	*	*	*	*	7
Ogle et al. (2014)	*		*	*	**	*		*	7

Valentino et al. (2012)		*	*	*	*	*	*	7
Valentno et al. (2009)	*	*	*	*	**	*	*	*	9
Stokes et al. (2004)	*			*	**		*	*	6

[1]Possible 9 stars, [2]Possible 7 stars (adapted measure), [3]Possible 9 stars. [4]Arie et al. (2008) was quality assessed as a case control study however the case definition applies here to clinical status (i.e. suicidal psychiatric group, psychiatric non suicidal control group and community control) rather than the case definition of a trauma group. The authors reported correlational (cross-sectional) data for the whole (mixed) sample when assessing the negative life events and OGM.

Table 2: *Summary of studies examining the trauma exposure*

Studies (year)	No. of participants (% male)	Sample (no. in group)	Age (mean and SD)	Type of trauma	Finding(s)	Support
Arie et al. (2008)	75 (Suicide attempt group = 35%; psychiatric control = 40%; community control = 48%)	Clinical: psychiatric inpatient (Suicide attempt group = 25; psychiatric control = 25; community control = 25). Psychiatric group who had attempted suicide with primary diagnoses of BPD, AN, CN, and MD. Psychiatric control group who had not attempted suicide with matched primary diagnoses and none of the control group had ever been in psychiatric treatment or had ever made a suicide attempt. Participants with significant comorbidity were excluded.	12 – 19 years (Suicide attempt group, M = 16.50 ± 2.5 years; psychiatric control, M = 16.50 ± 2.5 years; community control, M = 16.6 ± 2.3 years)	Life events (including but not exhaustive of events at school, parents, family and health events)	In comparison to the psychiatric and community control groups, negative life events in childhood were correlated with OGM in the suicide psychiatric group.	Yes
Brennen et al. (2010) study 1[1]	89 (Trauma group = 50%; control group = 46%)	Non-clinical trauma exposed groups recruited from schools: (Trauma group = 40; control group = 49). None of the sample had a current or previous clinical diagnosis.	17-19 years (Trauma group, M = 17.90, SD = 0.70; control group, M = 18.00, SD = 0.50)	War exposure	Bosnian group (war exposure) recalled fewer specific memoires and more categoric memories than the Norwegian group (non-war exposure group).	Yes
Crane et al. (2014)	5,792 (43%)	Non-clinical: Children from ongoing population study. Participants were assessed for probable cases of depression based on questions given to mothers, and responses assessed by clinical psychologists. Findings were noted including and excluding participants with probable depression.	13 years (95% between 13 years, 1 month & 13 years, 3 months)	Life events (severe events including but not exhaustive of death of a family member, physical or sexual abuse)	60% increase in the odds of low memory specificity at aged 13 for children who had experienced severe trauma in middle childhood.	Yes
de Decker et al. (2003)	27 (63%)	Clinical: Psychiatric inpatient population. No formal diagnoses were known but participants experiencing acute psychotic episodes were excluded.	14-20 years (M = 16.40, SD = 1.5)	Various events including but not exclusive of emotional neglect and abuse, physical abuse and sexual approach and abuse	Greater trauma was associated with less specificity. This effect was specific to positive cue words.	Yes

Hitchcock et al. (2014b)	50 (75%)	Non-clinical: Children attending hospital for a single incident accidental injury (exclusion of physical or sexual abuse and loss of consciousness or brain injury due to trauma). No previous diagnosis of depression, PTSD, or anxiety. Participants were not receiving psychological treatment or taking psychotropic medication at the time of testing. 24% reached clinical cut off for self-reported PTSD symptoms and 6% reached clinical cut off for self-reported symptoms of depression.	7 – 17 years (M = 11.90, SD = 3.31)	Adverse life events (including but not exhaustive of death of a family member)	Trauma history not uniquely associated with OGM.	No
Johnson et al. (2005)	134 (46%)	Non-clinical trauma exposed population recruited from an ongoing study: Exposure to family violence and sexual abuse. Clinical depression was not examined but almost one third of their sample scored above clinical cut-off for depression as measured via self-report.	Year 1: 6 – 12 years (M = 9.00, SD = 1.98; Year 6 : 12 – 18 years (M = 15.00, SD = 1.97)	Family violence and sexual abuse	Family violence or sexual abuse not related to specific memories or OGM at year 1 or 6.	No
Kuyken et al. (2006)	62 (Never depressed = 25%; depressed no trauma = 25%; depressed and trauma = 9%)	Clinical: Recruited through schools, child and adolescent mental health services, children's homes, advertisements placed in libraries, youth centres, coffee houses and local media (Never depressed = 28; depressed no trauma = 12; depressed + trauma = 22). Participants with substance abuse within the past 12 hr or incapacity to participate because of an acute, unstable, or severe mental or physical health problem were excluded.	12–18 (Never depressed, M=15.68, SD= 1.59; depressed no trauma, M=15.92, SD=1.51; depressed and trauma, M=16.23, SD = 1.38)	Events (including but not exhaustive of serious car accidents, physical assault, sexual abuse, severe violence)	Adolescents with MDD and a history of trauma were *less* overgeneral than adolescents with MDD with no trauma. However, when specific memories were analysed, adolescents with MDD and a history of trauma were less specific.	No (but yes with specific memories)
Meesters et al. (2000)	27 (trauma group = 30%; no trauma group = 29%)	Non clinical: Adolescents in youth care (Trauma = 10; no-trauma =17)	14-19 years (Trauma group, M = 16.50, SD = 1.3; no trauma group, M = 16.10, SD = 2.8)	Physical maltreatment, sexual abuse & neglect	Adolescents with a history of trauma have greater difficulty reporting autobiographical facts than adolescents without a history of trauma.	Yes

Neshat Doost et al. (2014)	103 (Bereaved = 50%; non-bereaved = 58%)	Non-clinical recruited from schools: (Bereaved = 70; non-bereaved = 33)	12-18 years (bereaved, M = 14.89, SD = 1.83; non-bereaved (M = 14.91, SD = 2.05)	Paternal death (10 + years ago) related to war	Bereaved group retrieved a lower proportion of specific memories and a higher proportion of categoric and extended memories than the non-bereaved group.	Yes
Nixon et al. (2013) study 1	67 (High acute PTSD stress = 36%; low acute PTSD stress = 71%; control = 66%)	Non-clinical: Children attending hospital for a single-incident trauma and hospitalised control for non-trauma related illnesses (High acute stress = 11; low acute stress = 24; control = 32)	8-17 years (High acute PTSD stress, M = 13.27, SD = 2.72; low acute PTSD stress, M = 12.33, SD = 2.90; control, M = 12.78, SD = 3.01)	Events including road traffic accidents, assault, burns	No differences unconstrained condition. However, when constrained to retrieve memories from the 24-hour period following trauma, children with higher levels of acute PTSD stress symptoms retrieved a *greater* number of specific memories. No differences unconstrained condition.	No
Nixon et al. (2013) study 2	67 PTSD (58%) Control (59%)	Clinical*: Trauma exposed children with PTSD receiving CBT treatment vs trauma-exposed but non-PTSD children recruited from the community (PTSD = 33; control = 34)	7-16 years (PTSD, M= 11.12, SD = 3.12; control, M = 11.06, SD = 2.10)	Events including road traffic accidents, assault, death of relative	Trauma exposed children with PTSD retrieved fewer specific memories compared to trauma exposed non-PTSD controls.	Yes
Ogle et al. (2013)	85: 49 adolescents (14% whole sample of 85)	Non-clinical recruited from a child maltreatment diagnostic and treatment centre: Childhood sexual abuse = 25; control = 24). The participant sample was free from serious disorders, which include, but is not exclusive of, mental retardation, schizophrenia, or autism (based on self-reported medical and psychiatric diagnoses, clinical records and measures included in their study).	14-17 years (M = 15.12, SD = 0.95)	Childhood sexual abuse	Adolescents without CSA histories reported more specific memories than adolescents with CSA histories.	Yes
Orbach et al. (2001)	50 (not stated)	Non-clinical groups recruited from an ongoing study: (Family violence = 34; control = 16)	8 – 12 years (M = 10.61, SD = 1.31)	Witnessed and/or actual family violence	No group differences in OGM in between children in the Family	No

					Violence (Victims of Abuse, Witnesses of Abuse, and Victims and Witnesses) and Comparison groups.	
Stokes et al. (2004)	24 (0%)	Non-clinical recruited from wide range of community sources: Burns group = 12; orthodontic controls = 12). One participant scored above the clinical cut off for self-reported depression, six for self-reported anxiety and four for self-reported PTSD.	11-16 years (M = 14 years)	Burns between 6 weeks old & 14 years (requiring treatment at hospital)	The burn group recalled significantly fewer specific memories and more extended memories (but not categorical memories).	Yes
Valentino et al. (2012)	49 (67%)	Clinical: Psychiatric inpatients with primary diagnoses of mood disorders, PTSD and behavioural disorders (Physical and sexual abuse = 30; no abuse = 19). Individuals meeting DSM-IV criteria for psychotic disorder, or moderate to severe intellectual deficiency were excluded.	7 -17 years (Total, M = 14.10, SD = 2.3; Abuse, M = 13.49, SD = 2.3; No abuse, M = 15.28, SD = 1.6)	Physical and sexual abuse	Abuse is not associated with OGM (but is in interaction with depression). When symptoms of depression were low, the abused group retrieved more OGM's than the non-abused group. At higher levels of symptoms of depression however, the non-abused group retrieved more OGM's than the abused group.	Yes (only in interaction with symptoms of depression)
Valentino et al. (2009)	192 (Sexual and physical abuse = 67%; neglected = 56%; non-maltreated = 47%)	Non-clinical trauma exposed recruited from the Department of Human Services because due to concern of child maltreatment. Non-maltreated participants were recruited from families receiving public assistance in the form of Temporary Assistance to Needy Families: (Sexual and physical abuse = 36; neglected = 34; non-maltreated = 115)	7 -13 years (total, M = 10.61, SD = 1.55; Sexual and physical abuse = M = 10.69, SD = 1.6; neglected = M = 10.78, SD = 1.7; non-maltreated = M = 10.51, SD = 1.5)	Neglect, physical and sexual abuse	Abused children recall more OGMs than did the neglected children and the non-maltreated children.	Yes

MDD = major depressive disorder; PR = partially remitted; PSY = psychiatric sample; prop = proportion, no. = number of; neg = negative.
[1] Follow up study 2 not included as mean age above 18 years old. *39% of sample failed to meet to full criteria for 1 of the 3 symptom clusters.

Table 3: *Summary of studies examining the mechanisms of the CaR-FA-X model*

Studies (year)	No. of participants (% male)	Sample (no. in group)	Age (mean and SD)	CaR-FA-X mechanism (task)	Finding(s)	Support CaR-FA-X model
Capture and Rumination Studies						
Park et al. (2004)	134 (Full MDD = 30%; PR-MDD = 26%; Non-MDD PSY = 38%; Control = 38%)	Clinical: Recruited from adolescent mental health services (Full MDD = 44; PR MDD = 31; Non-MDD PSY = 26; Control = 33). MDD & PRMDD has some comorbidity. Non-MDD PSY no past current of family history but met DSM-IV criteria for one or more psychiatric disorders. Control group recruited from a school, had no history of psychiatric disorder and with no family history of depression or anxiety or behavioural disorders within the past 3 months.	12-17 years: (Full MDD, M = 14.90, SD = 1.3; PR-MDD, M = 15.00, SD = 1.4; Non-MDD PSY, M = 13.70, SD = 1.4; Control, M = 14.60, SD = 1.3)	R: (Rumination vs. distraction induction)	Greater increase in OGM after rumination induction than with distraction in the MDD (collapsed with partially remitted) group only. This effect was specific to negative cue words.	R: Yes
Schoofs et al. (2012) study 1	126 (21%)	Non-clinical: Community sample recruited from schools. Participants who met criteria for a current major depressive episode on self-report measure were removed.	17-20 years (M = 17.57, SD = 0.66)	C: (high & low discrepant words) R: (brooding and reflective)	A greater proportion of specific memories were retrieved in response to LD cues compared to HD cues. A greater proportion of categoric memories were retrieved in response to HD cues compared to LD cues. BR and RP not associated with OGM. These findings were specific to positive cue words (negative cues not used).	C: Yes R: No
Scoofs et al. (2012) study 2	146 (45%)	Non-clinical: Community sample recruited from schools. Participants who met criteria for a current major depressive episode on self-report measure were removed.	16-19 years (M = 16.82, SD = 0.72)	C: (high low discrepant words) R: (brooding and reflective)	A greater proportion of specific memories were retrieved in response to LD cues compared to HD cues. A greater proportion of categoric memories were retrieved in response to HD cues compared to LD cues. BR and RP not associated with OGM. These	C: Yes R: No

					findings were specific to positive cue words (negative cues not used).	
Smets et al. (2013)	123 (45%)	Non-clinical: Community sample recruited from schools.	16-19 years (M = 17.30, SD = 0.50)	C: (self-discrepancy induction) R: (RRS; Dutch version)	Rumination was not associated with OGM before or after self-discrepant induction. However, greater symptoms of depression were related to increases in OGM and decreases in memory specificity following the self-discrepancy induction. These findings were specific to positive cue words (negative cues not used).	C: Yes (only in interaction with symptoms of depression) R: No
Valentino et al. (2009)	192 (Sexual and physical abuse = 67%; neglected = 56%; non-maltreated = 47%)	Non-clinical trauma exposed recruited from the Department of Human Services because due to concern of child maltreatment. Non-maltreated participants were recruited from families receiving public assistance in the form of Temporary Assistance to Needy Families: (Sexual and physical abuse = 36; neglected = 34; non-maltreated = 115).	7 -13 years (total, M = 10.61, SD = 1.55; Sexual and physical abuse = M = 10.69, SD = 1.6; neglected = M = 10.78, SD = 1.7; non-maltreated = M = 10.51, SD = 1.5)	C: Child and maternal self-representations	Negative self-representations positively associated with OGM (in abused and non-maltreated groups combined).	C: Yes
Functional Avoidance Studies						
Stokes et al. (2004)	24 (0%)	Non-clinical trauma exposed recruited from wide range of community sources: Burns group = 12; orthodontic controls = 12). One participant scored above the clinical cut off for self-reported depression, six for self-reported anxiety and four for self-reported PTSD.	11-16 years (M = 14 years)	TE: Burns between 6 weeks old & 14 years (parental reports) A: Impact event scale	In the burns group, reduced specificity was correlated with higher avoidance.	FA: Yes
Impaired executive control						
de Decker et al. (2003)	27 (63%)	Clinical: Psychiatric inpatient population. No formal diagnoses were known but participants experiencing acute psychotic episodes were excluded.	14-20 years (M = 16.40, SD = 1.5)	X: WM capacity	Working memory capacity not associated with memory specificity.	X: No

Johnson et al. (2005)	134 (46%)	Non-clinical trauma exposed population recruited from an ongoing study: Exposure to family violence and sexual abuse. Clinical depression was not examined but almost one third of their sample scored above clinical cut-off for depression as measured via self-report.	Year 1: 6 – 12 years (M = 9.00, SD = 1.98; Year 6: 12 – 18 years (M = 15.00, SD = 1.97)	X: WM capacity	WM capacity was not associated with OGM or memory specificity.	X : No
Meesters et al. (2000)	27 (trauma group = 30%; no trauma group = 29%)	Non-clinical trauma exposed adolescents in youth care (Trauma = 10; no-trauma =17).	14-19 years (Trauma group, M = 16.50, SD = 1.3; no trauma group, M = 16.10, SD = 2.8)	X: WM capacity	WM capacity not associated with AM.	X : No
Nixon et al. (2013) study 1	67 (High acute PTSD stress = 36%; low acute PTSD stress = 71%; control = 66%)	Non-clinical trauma exposed: Children attending hospital for a single-incident trauma and hospitalised control for non-trauma related illnesses (High acute stress = 11; low acute stress = 24; control = 32).	8-17 years (High acute PTSD stress, M = 13.27, SD = 2.72; low acute PTSD stress, M = 12.33, SD = 2.90; control, M = 12.78, SD = 3.01)	X : WM capacity	Greater WMC was associated with greater memory specificity.	X: Yes (partial)
Nixon et al. (2013) study 2	67 PTSD (58%) Control (59%)	Clinical*: Trauma exposed children with PTSD receiving CBT treatment vs trauma-exposed but non-PTSD children recruited from the community (PTSD = 33; control = 34).	7-16 years (PTSD, M= 11.12, SD = 3.12; control, M = 11.06, SD = 2.10)	X: WM capacity	WMC was not associated with memory specificity.	X : No
Nuttall et al. (2014)	227 (4 year olds = 52%; 5 year olds = 51%; 6 year olds = 48%)	Non-clinical: Community pre-school sample: (4 year olds = 79; 5 year olds = 63; 6 year olds =65).	4-6 years (4 year olds, M = 4.52, SD = 0.27; 5 year olds, M = 5.49, SD = 0.29; 6 year olds, M= 6.52, SD= 0.28)	X: Behavioural inhibition	Behavioural inhibition not association with OGM in the preschool sample.	X : No
Raes et al. (2010)	135 (47%)	Non-clinical: Community sample recruited from schools.	9-13 years (M = 10.53, SD = .66)	X: Inhibition	Lower levels of inhibitory control were associated with greater recall of categoric memories.	X :Yes

Valentino et al. (2012)	49 (67%)	Clinical: Psychiatric inpatients with primary diagnoses of mood disorders, PTSD and behavioural disorders (Physical and sexual abuse = 30; no abuse = 19). Individuals meeting DSM-IV criteria for psychotic disorder, or moderate to severe intellectual deficiency were excluded.	7 -17 years (Total, M = 14.10, SD = 2.3; Abuse, M = 13.49, SD = 2.3; No abuse, M = 15.28, SD = 1.6)	X: Shifting, inhibition, verbal fluency (letter & category fluency)	Shifting, letter fluency and inhibition not correlated with OGM Category fluency associated with greater OGM.	X: Yes (only for category fluency)
2 mechanisms						
Hitchcock et al. (2014b)	50 (75%)	Non-clinical trauma exposed: Children attending hospital for a single incident accidental injury. No previous diagnosis of depression, PTSD, or anxiety. Participants were not receiving psychological treatment or taking psychotropic medication at the time of testing. 24% reached clinical cut off for self-reported PTSD symptoms and 6% reached clinical cut off for self-reported symptoms of depression.	7 – 17 years (M = 11.90, SD = 3.31)	R: CRSS TE: trauma questionnaire X: WM capacity, WM updating, verbal fluency & inhibition R&X: Rumination x executive control	Rumination not associated with OGM. WM updating, verbal fluency and inhibition not associated with OGM. Greater WM capacity was associated with reductions in OGM (in older children) but greater WM in younger children was associated with greater OGM. Greater WM capacity and high levels of inhibition positively associated with OGM. No interactive effects between executive control and rumination.	R: No X: Yes (partial & only for WM capacity & older children) R&X: No
Kuyken et al. (2006)	62 (Never depressed = 25%; depressed no trauma = 25%; depressed and trauma = 9%)	Clinical: Recruited through schools, child and adolescent mental health services, children's homes, advertisements placed in libraries, youth centres, coffee houses and local media (Never depressed = 28; depressed no trauma = 12; depressed + trauma = 22). Participants with substance abuse within the past 12 hr or incapacity to participate because of an acute, unstable, or severe mental or physical health problem were excluded.	12–18 (Never depressed, M=15.68, SD= 1.59; depressed no trauma, M=15.92, SD=1.51; depressed and trauma, M=16.23, SD = 1.38)	A: The Children's Impact of Event Scale X: Verbal fluency	In the trauma plus MDD group, higher levels of avoidance w.as associated with *less* OGM Across the whole sample, verbal fluency was not associated with OGM.	FA: No X : No

AM = autobiographical memory; CRSS = The Children's Response Style Scale; MDD = major depressive disorder; PR = partially remitted; PSY = psychiatric sample; prop = proportion, no. = number of; neg = negative; RRS = ruminative response scale; BR = brooding rumination; RP = reflective pondering; LD = low discrepant, HD = high discrepant; ns = non-significant; R = rumination; C = capture; FA; functional avoidance; X = executive control. *39% of sample failed to meet to full criteria for 1 of the 3 symptom clusters.

Table 4: *Summary table of outcome measurement variations*

Assessment of OGM

Study (year)	Measure (author)	Time limit	Cue words	Cue delivery	Practice set	Memory type	Unit of measurement	Omissions
Arie et al. (2008)	AMT (no author but based on Williams & Broadbent, 1986)	60	10 words: Five words with positive connotations (happy, proud, calm, successful, surprised) and 5 words with negative connotations (sorry, angry, guilty, heart, lonely)	Not stated	No (they were given 2 additional chances, each with a 60-second limit if no specific memory was given within 60s)	OGM (all memories except specific and omission)	Number	Recorded
Brennen et al. (2010) study 1	AMT: (Williams & Broadbent, 1986). Norwegian and Bosnian translations	2 minutes	12: 5 positive (happy, safe, interested, successful, and surprised). 5 negative (sad, angry, clumsy, hurt, and lonely). 2 more positive words were included (optimistic and victory)	Oral	Yes	Specific, categoric, extended and no responses	Proportion	Recorded
Crane et al. (2014)	AMT: Williams & Broadbent, 1986). Written version	None	10: 5 positive (excited, happy, lucky, relaxed, relieved). 5 negative (bored, failure, hopeless, lonely, sad)	Written	No (examples were given)	Binary score used: lowest quartile (providing at most one specific memory response) versus the remainder	Number	Included as a non-specific memory
De decker et al. (2003)	AMT Dutch version (de Decker, 2001) of the AMT (Williams & Broadbent, 1986)	30 seconds	10: 5 positive (happy, safe, interested, successful, surprised), 5 negative (sad, angry, clumsy, emotionally hurt, lonely)	Oral	No	Specific	Number	Not stated
Hitchcock et al. (2014b)	AMT (Williams & Broadbent, 1986)	60 seconds	Three word sets (5 positive & 5 negative in each) Word set 1: Happy, sad, easy, lonely, proud, scared, brave, angry, successful, broken. Word set 2: Happy, sad, friend, stupid,	Written and oral	Yes	OGM (categoric and extended) and specific	Number	Recorded

			surprised, tears, smart, mad, playing, afraid. Word set 3: Happy, sad, beautiful, hurt, safe, sorry, lucky, upset, interested, alone					
Johnson et al. (2005)	AMT (Crovitz et al.,1980)	3 minutes	Not stated: three types of cue words: positive (e.g., “present,” “playing”), neutral (e.g., “car,” “shopping”), negative (e.g., “punishment,” “arguing”).	Not stated	Not stated	Specific and OGM (memories not containing at least one specific detail)	Number: Generate as many specific as possible from before age 9 in time limit	Not stated
Kuyken et al. (2006)	AMT (Williams, 2000).	30 seconds	10: 5 positive (happy, hopeful, excited, proud and loved) and 5 negative (lonely, frightened, sad, angry and ashamed)	Flashcards	Yes	OGM (categoric and extended) and specific	Number and proportions	Recorded
Meesters et al. (2000)	SAMT (Meesters at al., 2000)	Not stated	No cue words Sentences (e.g. the name of the street lived on)	Not stated	Not stated	No. of correct responses / by total no. of items - the number of non-relevant items	Number	Not stated
Neshat Doost et al. (2014)	AMT (Williams & Broadbent, 1986)	30 seconds	18: 6 positive (park , play , praise, party , celebration, holiday), 6 negative (accident , loneliness , argument, death break-up, illness), 6 neutral (year, book, class, clothes house, desk).	Written	Yes	Specific, categoric, extended, and semantic associates	Proportion (total of each memory type was divided by total no. of memories provided)	Recorded
Nixon et al. (2013) study 1	AMT: constrained and unconstrained[1] (Williams & Broadbent, 1986)	60 seconds	10: Ten affect words were presented on 5 positive (happy, brave, safe, strong, interested), 5 negative words (lonely, doubt, hurt, strange, clumsy)	Flashcards	Yes	Specific	Number and proportion (relative to the number of specific, overgeneral and omissions)	Recorded
Nixon et al. (2013) study 2	AMT (Williams & Broadbent, 1986)	60 seconds	10: Ten affect words were presented on 5 positive (happy, brave, safe, strong, interested)	Flashcards	Yes	Specific	Number and proportion (relative to	Recorded

			5 negative words (lonely, doubt, hurt, strange, clumsy)				the number of specific, overgeneral and omissions)	
Nuttall et al. (2014)	AMT-PV[2] (Nuttall et al., 2014)	60 seconds	10: 5 positive (happy, surprised, lucky, strong, smart), 5 negative (mad, sad, scared, tired, hungry)	Oral and visually	Not stated	Specific (coded 1 for specific and 0 for all other memories)	Number	Coded as OGM
Ogle et al. (2013)	The AMI[3] (Kopelman et al., 1989)	None	No cue words: recalled an incident that occurred in elementary school (Grades 1–5; aged 5–10), and an incident that occurred during sixth grade (aged 12)	Not stated	No (examples were given)	Specific (4 point rating scale)	Number	Recorded
Orbach et al. (2001)	The FDQ[4] (Salzinger, Feldman, Hammer, & Rosario, 1992)	Not stated	No cue words: Questions asked the child to describe issues, incidence, and characteristics of child-parent and interparental disagreements, arguments, disputes, parental punishment, and parental physical violence	N/A	No	Categoric	Proportion (relative to the number of responses)	Recorded
Park et al. (2004)	AMT (Williams & Broadbent, 1986)	60 seconds	4 word sets were used (6 positive & 6 negative in each set) Word set 1: happy, relieved, proud, eager, glorious, sunny, guilty, hopeless, grave, ugly, worse, failure; Word set 2: interested, hopeful, amazed, pleased, calm, bright, grief, rejected, lonely, blame, awful, mistake; Word set 3: joy, smile, loyal, lively, cheer, lucky, sad, misery, ashamed, weakness, angry, tired; Word set 4: safe, excited, friendly, peaceful, successful, pleasant, tragic, upset, hurt, bad, bored, fault	Flashcards	Yes	Categoric	Proportion	Recorded
Raes et al. (2010)	AMT: Written version	Not stated	10: 5 positive (happy, relaxed, successful, brave, proud), 5 negative (scared, lonely, angry, sad, guilty)	Written	Not stated	Categoric	Number	Recorded

	(Williams & Broadbent, 1986)							
Schoofs et al. (2012) study 1& 2	Mi-AMT: written version (Williams & Broadbent, 1986) (Written; Debeer et al., 2009)	60 seconds	20 words: Only positive 10 high discrepant (example - optimistic, successful, and satisfied); 10 low discrepant (example - sensitive, grateful, and polite)	Not stated	No	Specific and Categoric	Proportion (no. of specific memories / by no. of total responses (10 - no. of no responses)	Excluded in proportion calculations
Smet et al. (2013)	Mi-AMT: written version (Williams & Broadbent, 1986) (Written; Debeer et al., 2009)	60 seconds	20 words: Only positive 10 high discrepant (example - optimistic, successful, and satisfied); 10 low discrepant (example - sensitive, grateful, and polite)	Read aloud	No	Specific and categoric	Number and proportion	Recorded (excluded in calculation of specificity scores)
Stokes et al. (2004)	Cued recall task (no author)	60 seconds	10 emotional cue words. 5 positive cue words (Happy, Safe, Interested, Successful, Surprised) 5 negative words (Sorry, Angry, Clumsy, Hurt, Lonely)	Not stated	No (examples were given)	Specific, extended, categoric and omissions	Number and proportion (of total number of responses)	Recorded
Valentino et al. (2012)	AMT (Williams & Broadbent, 1986)	60 seconds	10 cue words: 5 positive and 5 negative (example - happy, sorry)	Oral and visual	Not stated	OGMs defined as memories that did not contain at least one specific detail	Number	Not stated
Valentino et al. (2009)	AMT (Williams & Broadbent, 1986)	60 seconds	10: 5 positive cue words (Happy, Safe, Interested, Successful, Surprised), 5 negative words (Sorry, Angry, Clumsy, Hurt, Lonely)	Oral and visual	Not stated	OGMs defined as memories that did not contain at least one specific detail	Number	Not stated

[1] Unconstrained condition = recall a specific event from any time period of their life, prior to the recent trauma/hospital admission. Constrained condition = recall a specific event from the time of trauma, up to 24 hours following the event in response to the cue words. [2] The AMT-PV is an adaptation of the original AMT (Williams & Broadbent, 1986) that was designed to be developmentally appropriate for pre-school children. [3]AMI = Autobiographical memory interview (Kopelman et al., 1989) [4]FDQ = Family Disagreements Questionnaire (FDQ: Salzinger, Feldman, Hammer, & Rosario, 1992). AMT = autobiographical memory test; Mi-AMT = minimal instruction autobiographical memory test; OGM = overgeneral memory.

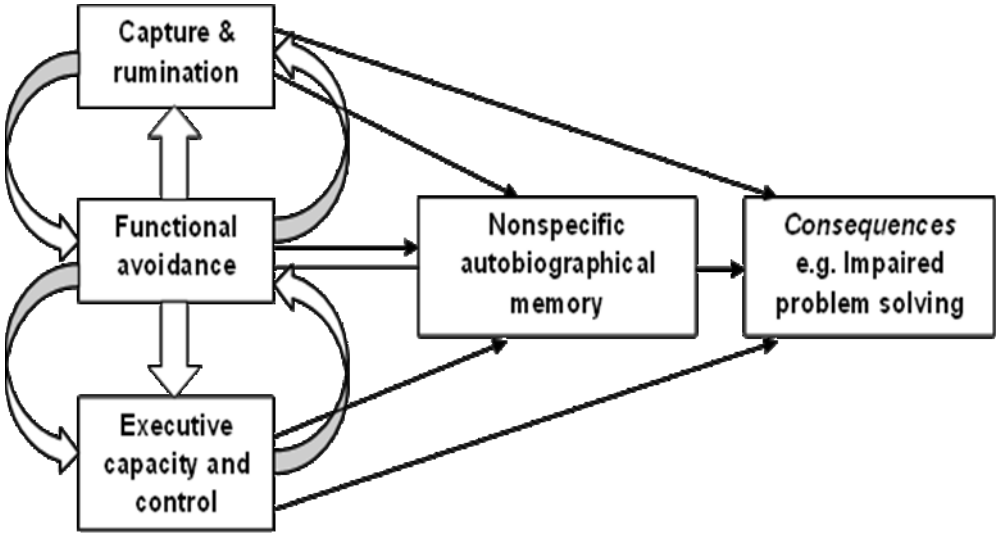

Figure 1: *The CaR-FA-X model. Three processes contributing to overgeneral memory—capture and rumination (CaR), functional avoidance (FA), and impaired executive capacity and control (X)—can each have effects on cognition and behaviour (e.g., problem solving), either independently or through their individual or combined effect on autobiographical memory (permission granted for reproduction of image from Professor J Mark G Williams).*

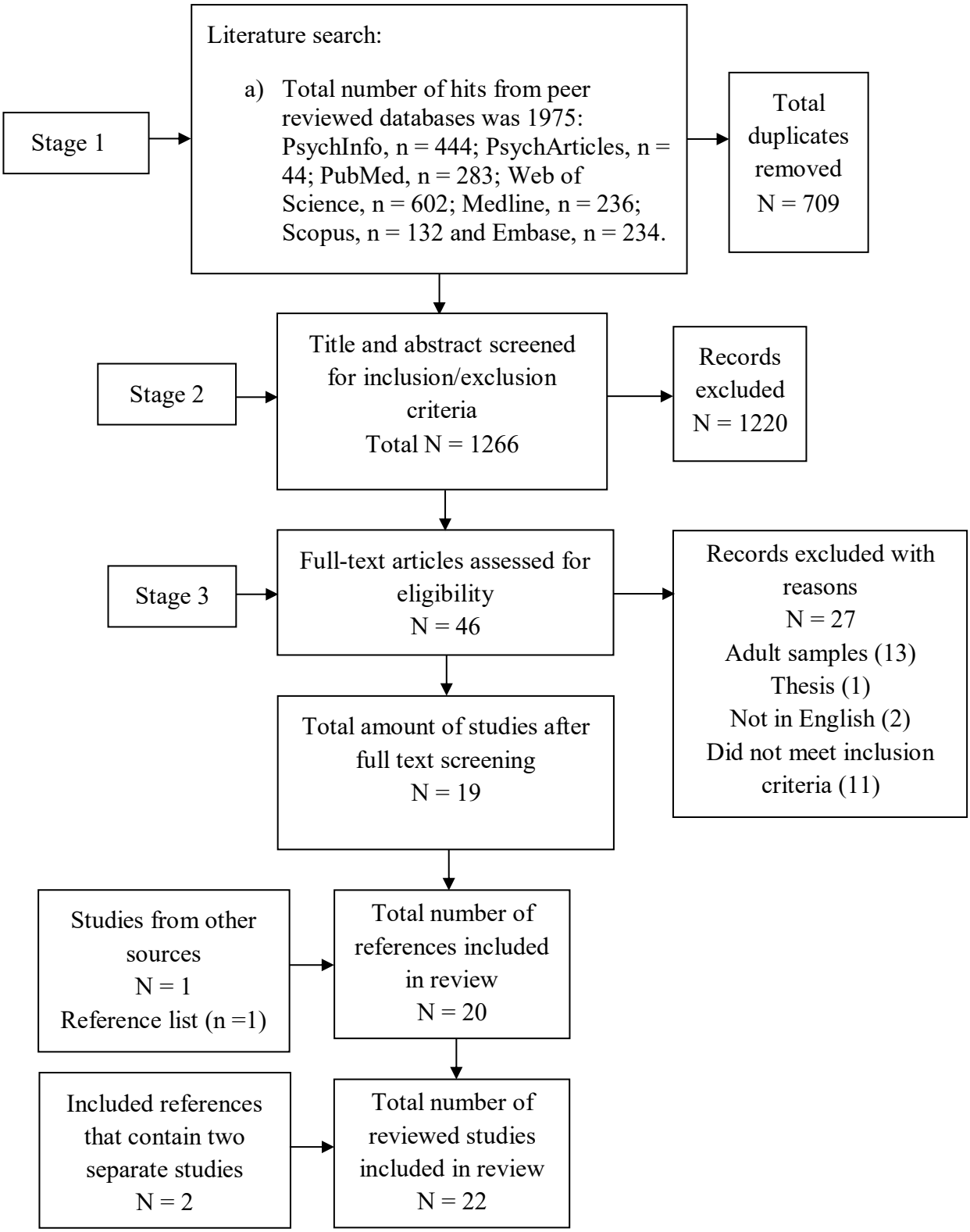

Figure 2. *Summary of database search*

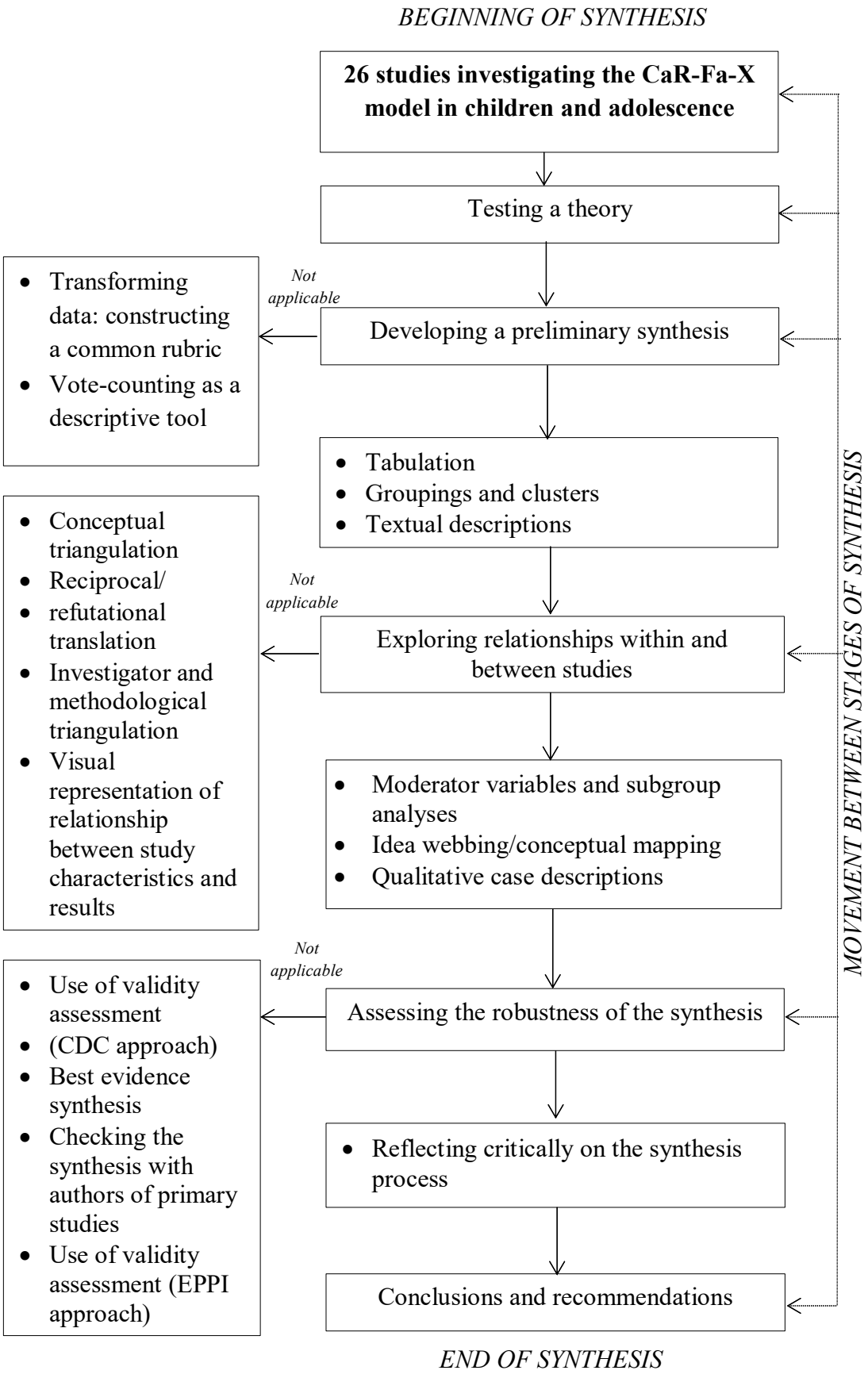

Figure 3: *Narrative synthesis*